S9086-SD-STM-010/CH-532R2

REVISION 2

NAVAL SHIPS' TECHNICAL MANUAL

CHAPTER 532

LIQUID COOLING SYSTEMS FOR ELECTRONIC EQUIPMENT

THIS CHAPTER SUPERSEDES CHAPTER 532 DATED 1 JULY 1992

PUBLISHED BY DIRECTION OF COMMANDER, NAVAL SEA SYSTEMS COMMAND

1 SEP 1999

NAVSEA TECHNICAL MANUAL CERTIFICATION SHEET 1 of 1

Certification Applies to: New Manual ☐ Revision ☒ Change ☐

Applicable TMINS/Pub. No. S9086–SD–STM–010/CH–532R2

Publication Date (Mo, Da, Yr) September 1999

Title: NSTM Chapter 532, Liquid Cooling Systems for Electronic Equipment

TMCR/TMSR/Specification No:

CHANGES AND REVISIONS:

Purpose: Side bars in the outside margin indicate changes since the last revision. This chapter was reformatted to support conversion to SGML and electronic distribution. Technical changes requested by the Life Cycle Manager have been incorporated but the chapter has not yet been approved by the Technical Authority.

Equipment Alteration Numbers Incorporated:

TMDER/ACN Numbers Incorporated:

Continue on reverse side or add pages as needed.

CERTIFICATION STATEMENT

This is to certify that responsible NAVSEA activities have reviewed the above identified document for acquisition compliance, technical coverage, and printing quality. This form is for internal NAVSEA management use only, and does not imply contractual approval or acceptance of the technical manual by the Government, nor relieve the contractor of any responsibility for delivering the technical manual in accordance with the contract requirement.

Authority	Name	Signature	Organization	Code	Date
Acquisition					
Technical	V.A. COPOLLA, JR		NAVSEA	05L34	8/24/92
Printing Release	Digital Media Publishing				

Certification Sheet

TABLE OF CONTENTS

TABLE OF CONTENTS - Continued

TABLE OF CONTENTS - Continued

LIST OF TABLES

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS - Continued

NOTE

THIS CHAPTER HAS BEEN REFORMATTED FROM DOUBLE COLUMN TO SINGLE COLUMN TO SUPPORT THE NSTM DATABASE. THE CONTENT OF THIS CHAPTER HAS NOT BEEN CHANGED.

CHAPTER 532

LIQUID COOLING SYSTEMS FOR ELECTRONIC EQUIPMENT

SECTION 1.
INTRODUCTION

532-1.1 BACKGROUND.

Liquid cooling systems vary from ship to ship with respect to the number and type of electronic equipment that require cooling water, the system components, and the cooling medium employed. Examples of electronic systems that require cooling are radar, sonar, and the Naval Tactical Data System (NTDS).

532-1.2 INTERLOCKING FEATURES.

In the operation and servicing of these systems, their interlocking features must be recognized. Frequently, one system may serve sonar, fire control, and data systems equipment, and may utilize a separate seawater circulating system, the firemain, and the chilled water system.

532-1.2.1 During operation and servicing, possible adverse effects upon these interlocking equipment and systems must be recognized and avoided.

532-1.3 TECHNICAL ASSISTANCE.

Naval Ship Systems Engineering Station (NAVSSES), Carderock Division, Naval Surface Warfare Center (NSWC) has been designated as the In- Service Engineering Agent (ISEA) for electronic cooling water systems. Naval Ship Systems Engineering Station (NAVSSES), Carderock Division, Naval Surface Warfare Center (NSWC) responsibilities include updating and maintaining configuration databases and Integrated Logistics Support (ILS) documents, as well as providing design, repair, and fleet engineering services. Requests for technical assistance in any of the areas listed above should be directed to The Naval Ship Systems Engineering Station (NAVSSES), Carderock Division, Naval Surface Warfare Center (NSWC), Code 024C, Philadelphia, PA.

532-1.3.1 Requests for Direct Fleet Support (DFS) should be made through the appropriate Type Commander or Readiness Support Group (RSG). Naval Sea Support Center, Atlantic (NAVSEACENLANT), Norfolk, VA, Code 532 and Naval Sea Support Center, Pacific (NAVSEACENPAC), San Diego, CA, Code 730, are available for direct fleet support.

532-1.4 SAFETY PRECAUTIONS

532-1.4.1 The electronic installation should not be operated without cooling water. In conducting tests and maintenance of the cooling system, a continued awareness of the hazards to personnel working around electronic equipment is required (see **NSTM Chapter 400, Electronics**).

532-1.4.2 Cleaning solutions and other chemicals used for cooling water systems are hazardous if not handled correctly (see**NSTM Chapter 670, Stowage, Handling, and Disposal of Hazardous General Use Consumables).**

SECTION 2.

SYSTEM AND COMPONENT DESCRIPTION

532-2.1 GENERAL

532-2.1.1 This section provides a system approach to the operation and maintenance of liquid cooling systems. It is not intended to be a replacement for existing component technical manuals and applicable Planned Maintenance System (PMS) requirements.

532-2.1.2 Each of the components that constitute the system performs a function related to the operation of the entire system. A knowledge of the system requirements and operation, as well as those of each component, therefore, is essential to ensure reliable shipboard service.

532-2.1.3 Reference should be made to the applicable ship information books and technical manuals for detailed information on a particular system or component. Table 532-2-1 is provided as a ready reference.

532-2.2 STANDARD LIQUID COOLING SYSTEM

532-2.2.1 The standard liquid cooling system for electronic equipment is divided into two basic systems - primary and secondary systems.

532-2.3 PRIMARY SYSTEM

532-2.3.1 The primary system consists of the piping and components that provide the initial source of cooling water.

532-2.3.1.1 The sources of cooling water for the primary cooling system are seawater from the firemain system or from a dedicated seawater pump, or chilled water from the air conditioning plant. Figure 532-2-1, Figure 532-2-2, Figure 532-2-3, Figure 532-2-4, and Figure 532-2-5 illustrate basic arrangements using seawater and chilled water. Figure 532-2-1 and Figure 532-2-2 show seawater as the primary source of cooling water and also as a standby source; Figure 532-2-3 and Figure 532-2-4 show seawater as the primary source of cooling water and chilled water as a standby source; and Figure 532-2-5 shows chilled water as the primary source of cooling water and also as a standby source. The criteria used to determine whether seawater or chilled water is used for primary cooling is the required delivery temperature of the demineralized water to the ships electronic components. Seawater with seawater standby is used for demineralized water delivery temperatures of 100°F and above. Seawater with chilled water standby is used for demineralized water delivery temperatures of 80°F to 99°F maximum. Chilled water with chilled water standby is used for demineralized water temperatures of 80°F and below.

532-2.3.1.2 The primary means of providing seawater is via the ship's firemain, as illustrated in Figure 532-2-1, Figure 532-2-2, Figure 532-2-3, and Figure 532-2-4. The seawater is taken from the firemain through a strainer and flow regulator (e.g. pressure reducing valve or orifice plate) to the heat exchanger and overboard. A hose valve located prior to the strainer and regulator is provided to allow supply of seawater from another source for emergency service. The point at which piping branches off the firemain to supply cooling to various equipments is the point at which it becomes known as the Auxiliary Seawater System. Valve handwheels for the Seawater System should be painted red, and handwheels for the Auxiliary Seawater System should be painted green.

532-2.3.1.3 An alternate method for supplying seawater is by use of a dedicated seawater pump. A backup source of seawater may be provided via the firemain system with auto-switchover capability should the dedicated pump fail. A continuous vent line is provided at the pump casing and downstream of the pump discharge.

532-2.3.1.4 The auxiliary seawater system is a multiple-branch system supplying a number of heat exchangers. To regulate the proper amount of seawater to the heat exchangers, a flow/pressure regulator device is located in the piping upstream of each heat exchanger.

532-2.3.1.5 The heat exchanger is referred to as the seawater to demineralized water or chilled water to demineralized water heat exchanger.

532-2.3.1.6 The seawater systems are referred to as open-loop or one-pass systems because the water flows once through the system.

532-2.3.1.7 Chilled water is taken from the supply main of the air conditioning chilled water systems as a source of cooling water for the primary cooling system. This is illustrated in Figure 532-2-3, Figure 532-2-4, and Figure 532-2-5.

Table 532-2-1 SYSTEM SCHEMATIC LEGEND

	GLOBE VALVE		DUPLEX STRAINER BASKET TYPE
	GATE VALVE		"Y" STRAINER BASKET TYPE
	PRESSURE VALVE		CONSTANT FLOW REGULATOR
	RELIEF VALVE		ORIFICE
	3-WAY BALL VALVE		VENTURI
	BALL VALVE		AUTOMATIC VENT
	2-WAY TEMPERATURE REGULATING VALVE		HIGH TEMPERATURE ALARM SWITCH
	SWING CHECK VALVE		LOW LEVEL ALARM SWITCH
	GATE VALVE, LOCKED OPEN		LOW FLOW SWITCH
	THERMOMETER		FLOWMETER
	PRESSURE GAGE		BUTTERFLY VALVE
	VACUUM/PRESSURE GAGE	NS	NORMALLY SHUT
	DIAL TYPE FLOW METER		CAPILLARY TUBING
	DIFFERENTIAL PRESSURE GAGE		CHILLED WATER LINES
	DUPLEX PRESSURE GAGE		DEMINERALIZED WATER LINES
			SEAWATER LINES

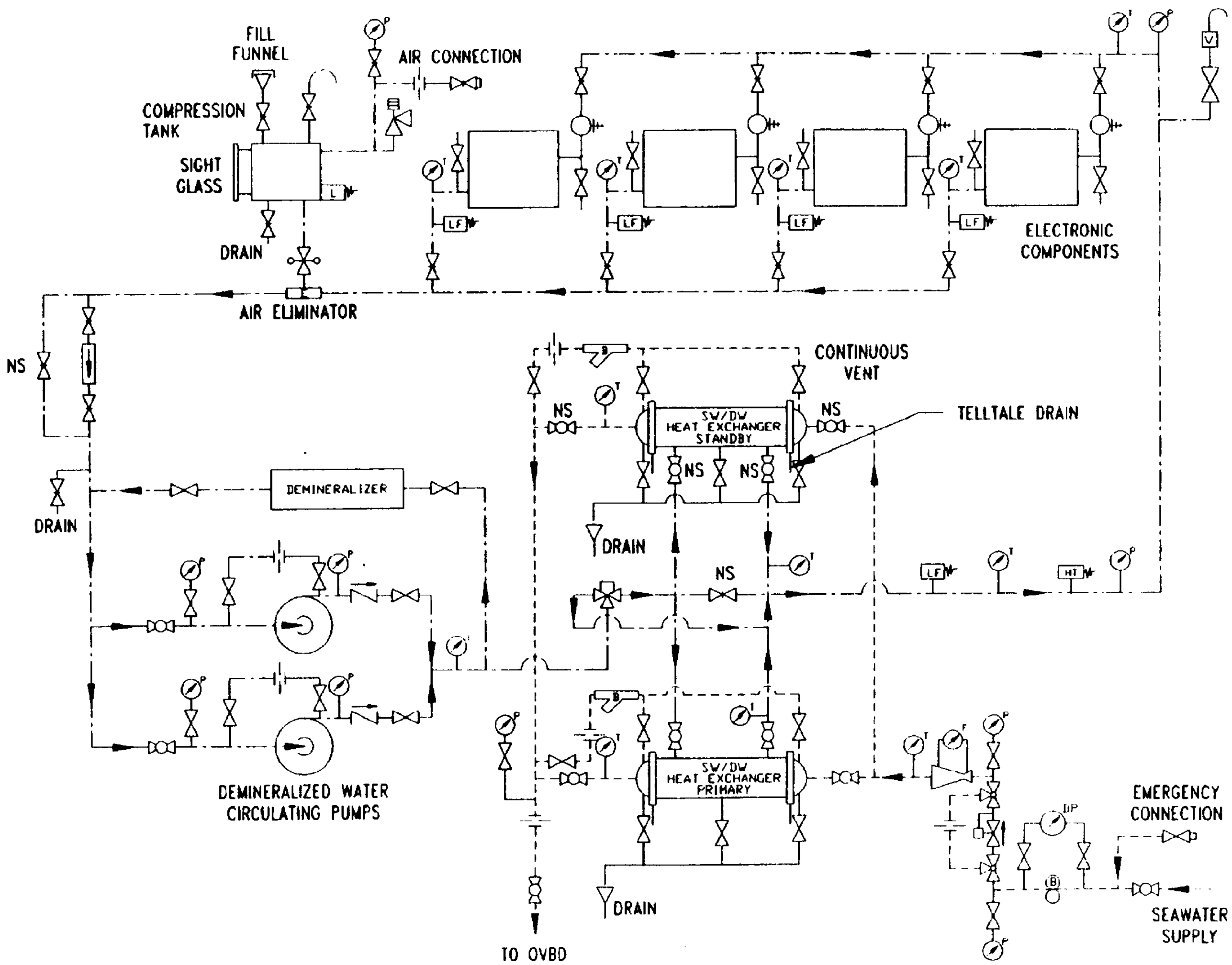


Figure 532-2-1 Seawater/Demineralized Water Shell and Tube Heat Exchanger with Seawater/Demineralized Water Shell and Tube Heat Exchanger Standby

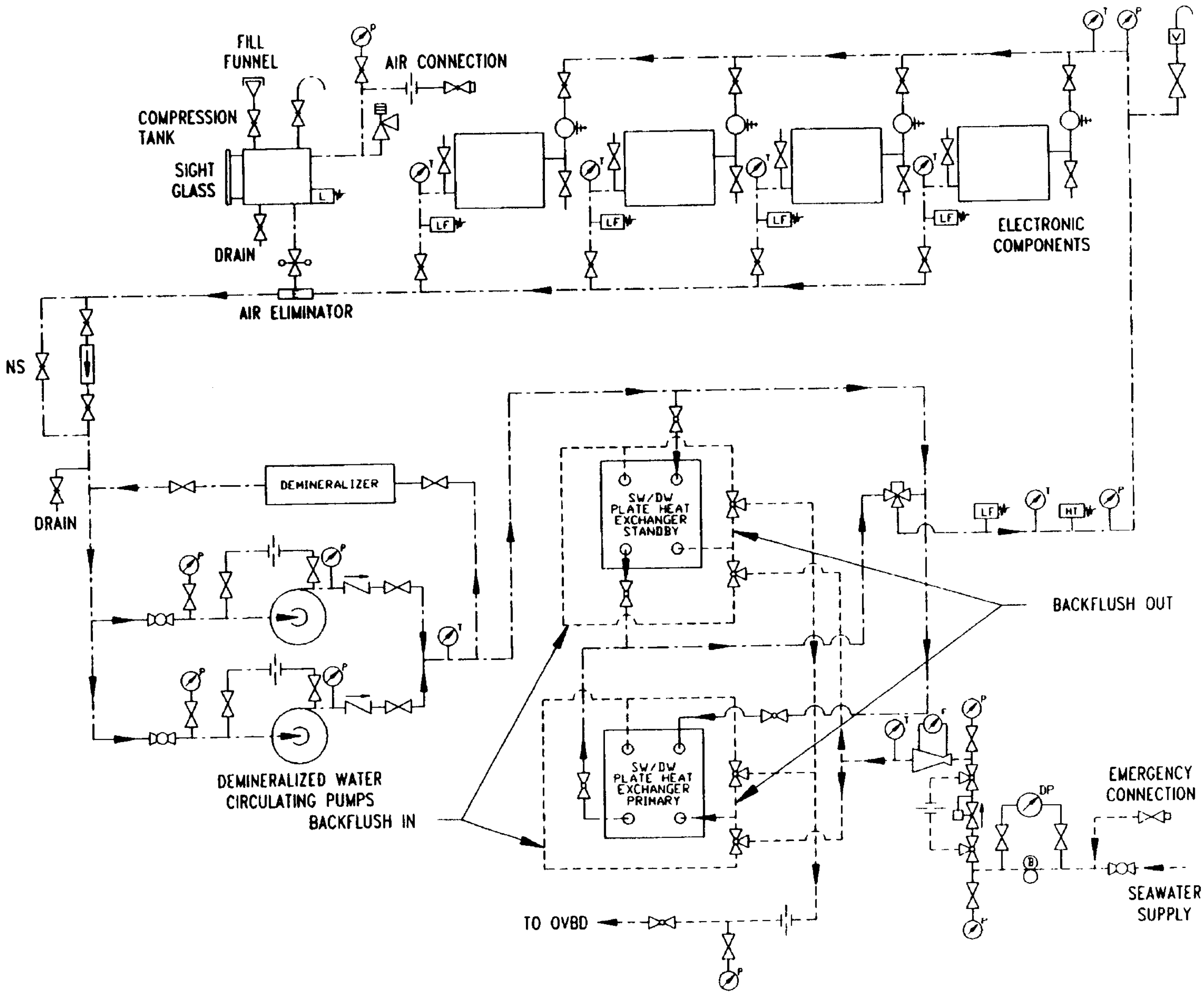


Figure 532-2-2 Seawater/Demineralized Water Plate Heat Exchanger with Seawater/Demineralized Water Plate Heat Exchanger Standby

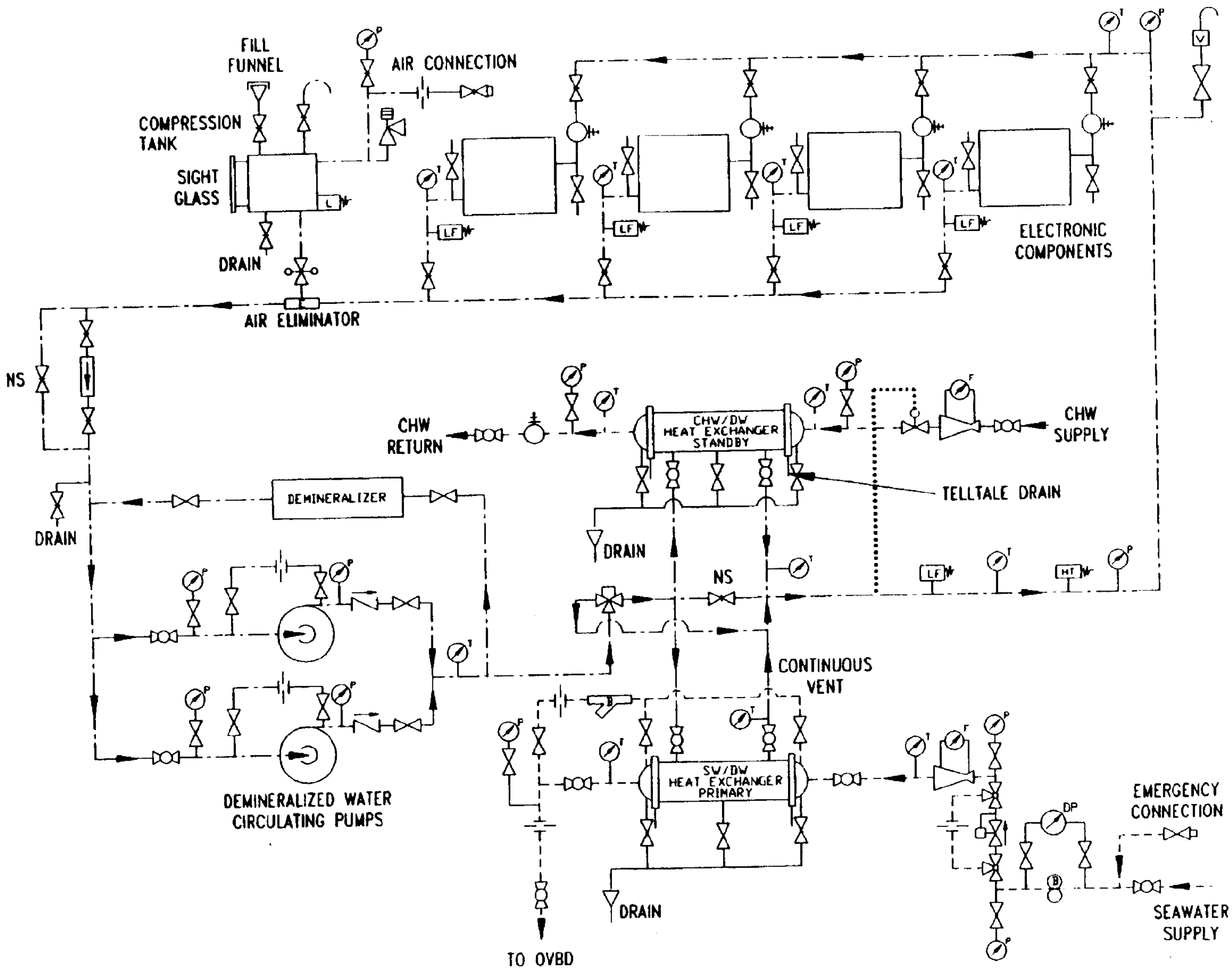


Figure 532-2-3 Seawater/Demineralized Water Shell and Tube Heat Exchanger with Chilled Water/ Demineralized Water Shell and Tube Heat Exchanger Standby

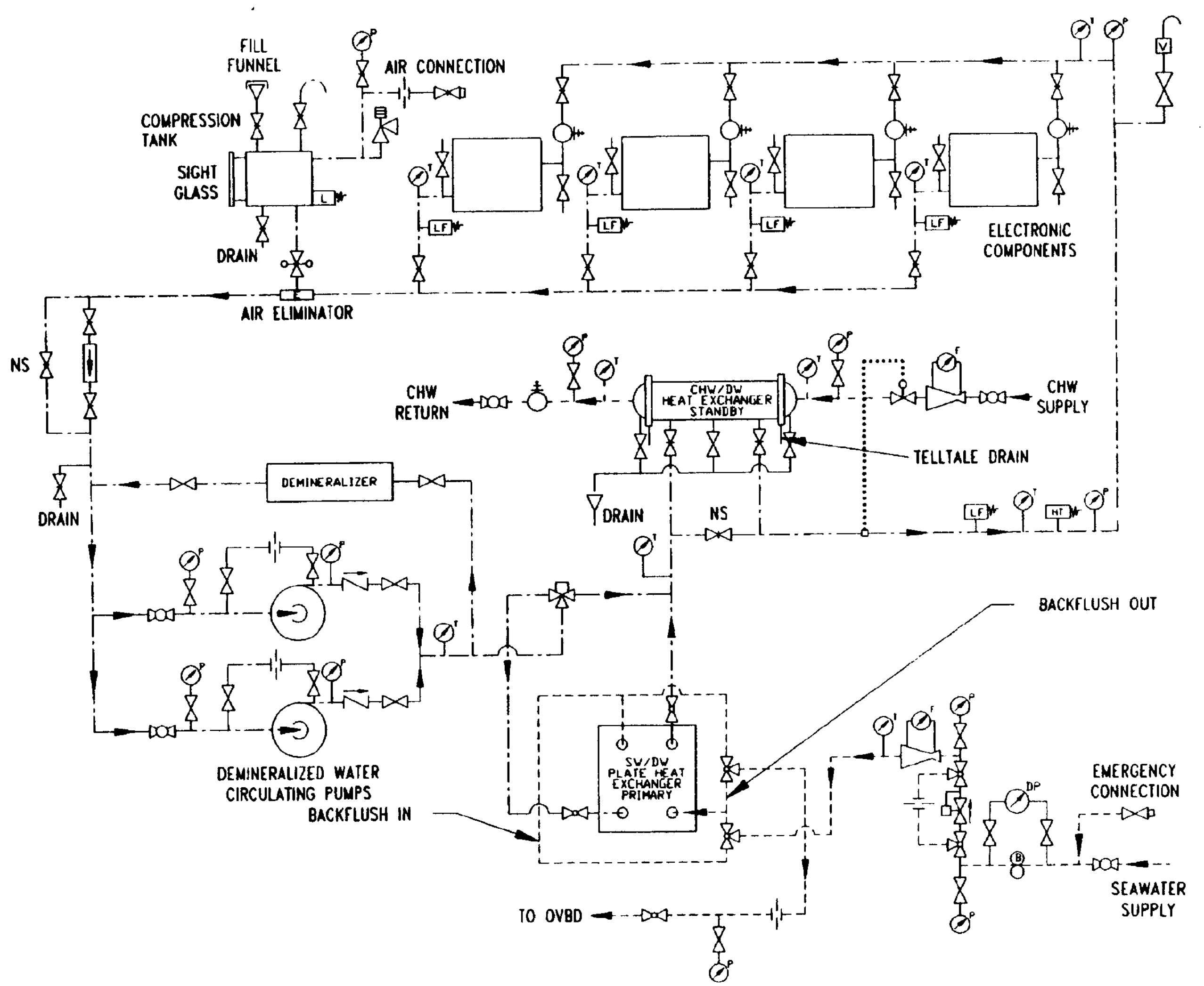


Figure 532-2-4 Seawater/Demineralized Water Plate Heat Exchanger with Chilled Water/Demineralized Water Shell and Tube Heat Exchanger Standby

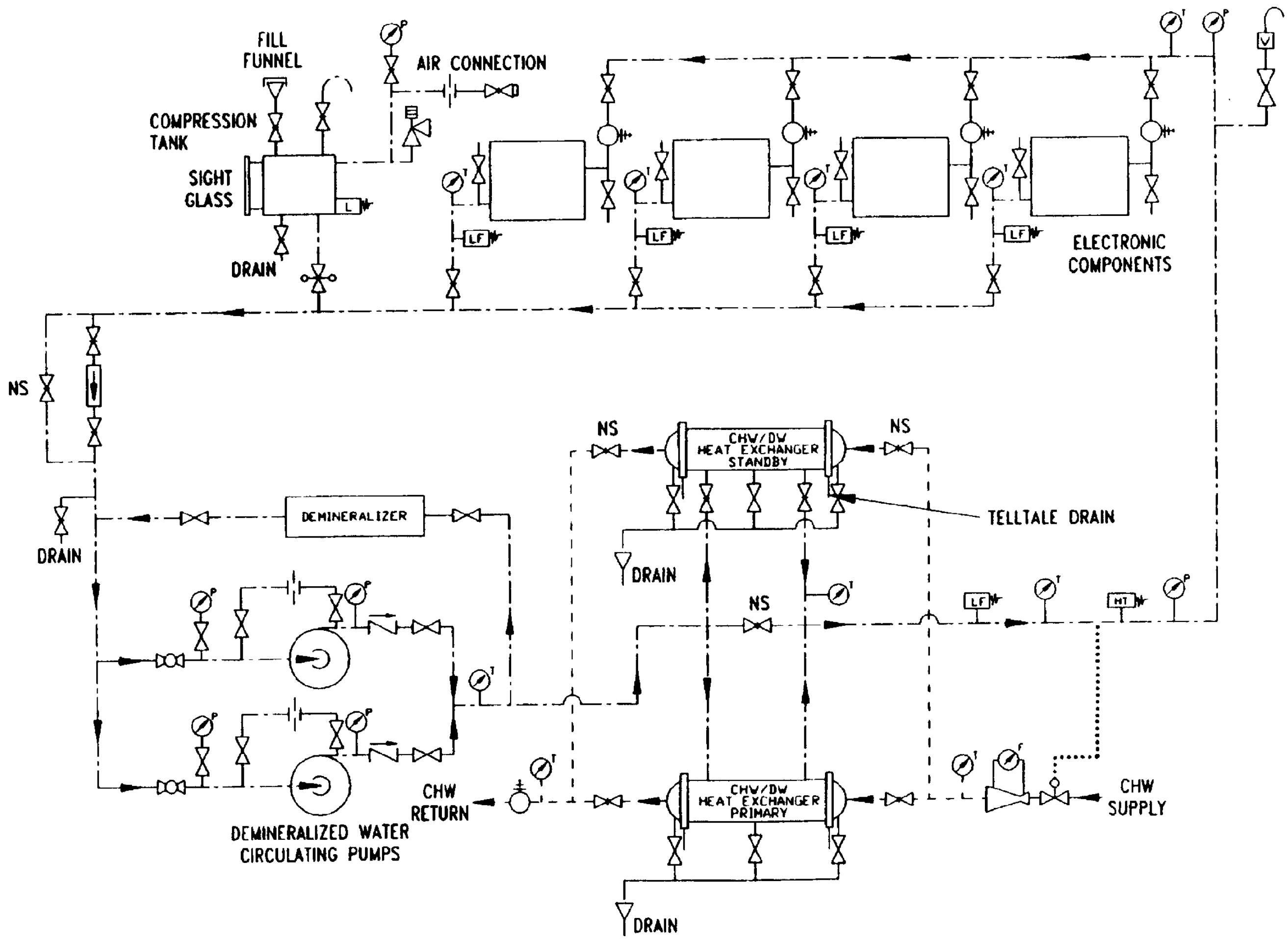


Figure 532-2-5 Chilled Water/Demineralized Water Shell and Tube Heat Exchanger with Chilled Water/ Demineralized Water Shell and Tube Heat Exchanger Standby

532-2.3.1.8 The chilled water flows through the heat exchanger (chilled water to demineralized water), flow regulator, and back to the chilled water system. A temperature-regulating valve at the inlet of the heat exchanger regulates the flow of chilled water through the heat exchanger to maintain a required water temperature in the demineralized water system.

532-2.3.1.9 The chilled water system is a closed-loop water system that must be kept tight and free from leaks to insure satisfactory operation.

532-2.4 SECONDARY SYSTEM

532-2.4.1 The secondary system consists of piping and components that transfer heating load from electronic equipment to the primary system.

532-2.4.1.1 The cooling medium used in the secondary cooling system is distilled water, the purity of which will vary, depending on requirements of the electronic equipment, from normal ship's distilled water to ultrapure water maintained by a demineralizer. Examples range from a low purity system with a limit of 5 grains per gallon or 1.3 equivalents per million (epm) to a high purity system with a limit of 2.0 micromhos/cm (max) conductivity.

532-2.4.1.2 Distilled water systems that have branch lines exposed to weather use ethylene glycol mixed with distilled water to prevent freezing. A typical ethylene glycol and distilled water system would have a limit of 383 grains per gallon (100 epm) of chloride, or 14,500 micromhos/cm (max) conductivity.

532-2.4.1.3 To determine the required water purity of a distilled water system, the applicable technical manual should be consulted. Many manuals refer to a low purity distilled water system as a freshwater cooling system. Past confusion resulted in treated potable or boiler water being used instead of untreated distilling plant water. The chemical treatment reacted with the system material and created a serious fouling problem. Section 4 includes recommended sources of water for the system.

532-2.4.1.4 Most electronic components require demineralized water, therefore the term ″demineralized water″ is used throughout this section in referring to the secondary system.

532-2.4.1.5 The demineralized water circulating pump discharges water to the sea-water-to-demineralized-water (SW/DW) or chilled-water-to-demineralized-water (CHW/DW) heat exchanger. The standby heat exchanger is similar in design and should be used when the on-line heat exchanger is inoperative, or when one heat exchanger is not capable of handling the entire heat load (this could be the case if the seawater supply temperature is extremely high).

532-2.4.1.6 A three way temperature-regulating valve is installed to bypass demineralized water around the seawater-to-demineralized-water heat exchanger, as required, to maintain a constant water temperature supplied to the electronic components. For systems with chilled water heat exchangers, a sensing bulb in the demineralized water system is connected to a two way temperature regulating valve to allow chilled water to flow through the heat exchanger.

532-2.4.1.7 The cooled demineralized water is supplied to the electronic equipment. Each electronic equipment is provided with a flow regulator (Figure 532-2-6) to regulate the desired flow along with inlet and outlet isolation valves, an outlet temperature gage and drains and vents on the inlet and outlet piping. A flow switch may also be provided to indicate a low flow condition.

532-2.4.1.8 The inlet and outlet connections from the electronic equipment to the system ″hard piping″ are flexible hoses which facilitate maintenance and replacement and are required when electronic equipment is resiliently mounted. From the electronic equipment the demineralized water is returned to the suction of the circulating pump.

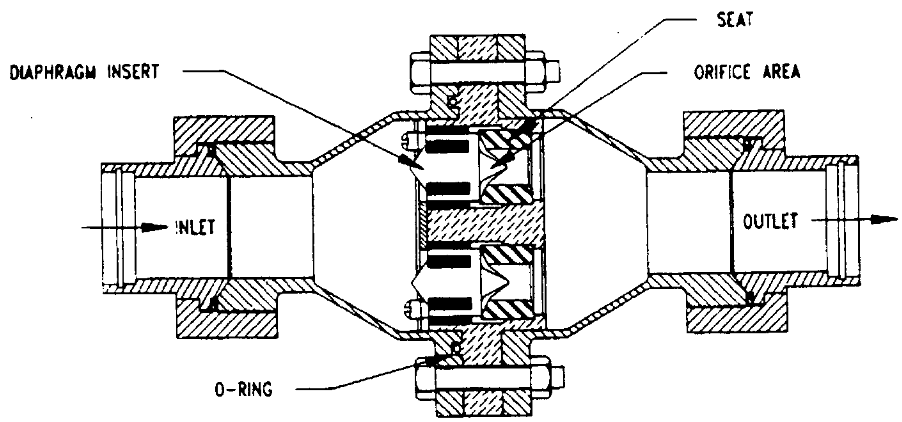


Figure 532-2-6 Constant Flow Regulator

532-2.4.1.9 On those systems where a high purity distilled water is required, a demineralizer is installed in-line between the pump discharge and suction. A flow meter and globe valve are provided so that the operator can adjust the flow through the demineralizer to pass approximately five percent of the total system volume per hour through the demineralizer. The demineralizer is designed to remove solids, metallic and hard water ions, carbon dioxide, and oxygen. In addition, a submicron filter is installed downstream of the demineralizer to prevent cartridge resin beads and resin particulate from entering the system should a cartridge fail. A low flow switch is provided to warn of low flow through the demineralizer. A purity meter measures inlet and outlet water purity and an alarm warns of low purity water.

532-2.4.1.10 An expansion tank is provided in the demineralized water system to compensate for changes in the coolant volume and to provide a source of make-up water in the event of a system leak. The tank is installed in a branch line connected to the suction side of the circulating pump. When used as a gravity tank, the tank is located above the highest point in the system and vented to atmosphere. When used as a compression tank, the tank is located near the circulating pump and charged with air pressure.

532-2.4.1.11 The demineralized water system is a closed-loop water system, as compared to the seawater system, which is a one-pass open-loop system. Satisfactory operation of the demineralized water system, therefore, requires that the system be kept tight, repairing all leaks encountered.

532-2.5 CIRCULATING PUMP

CAUTION

The circulating pumps in some demineralized water systems are not provided with a recirculating line. Prolonged operation of the pump without flow of water through the pump will result in overheating and seizure. Never operate any pump with the suction valve closed.

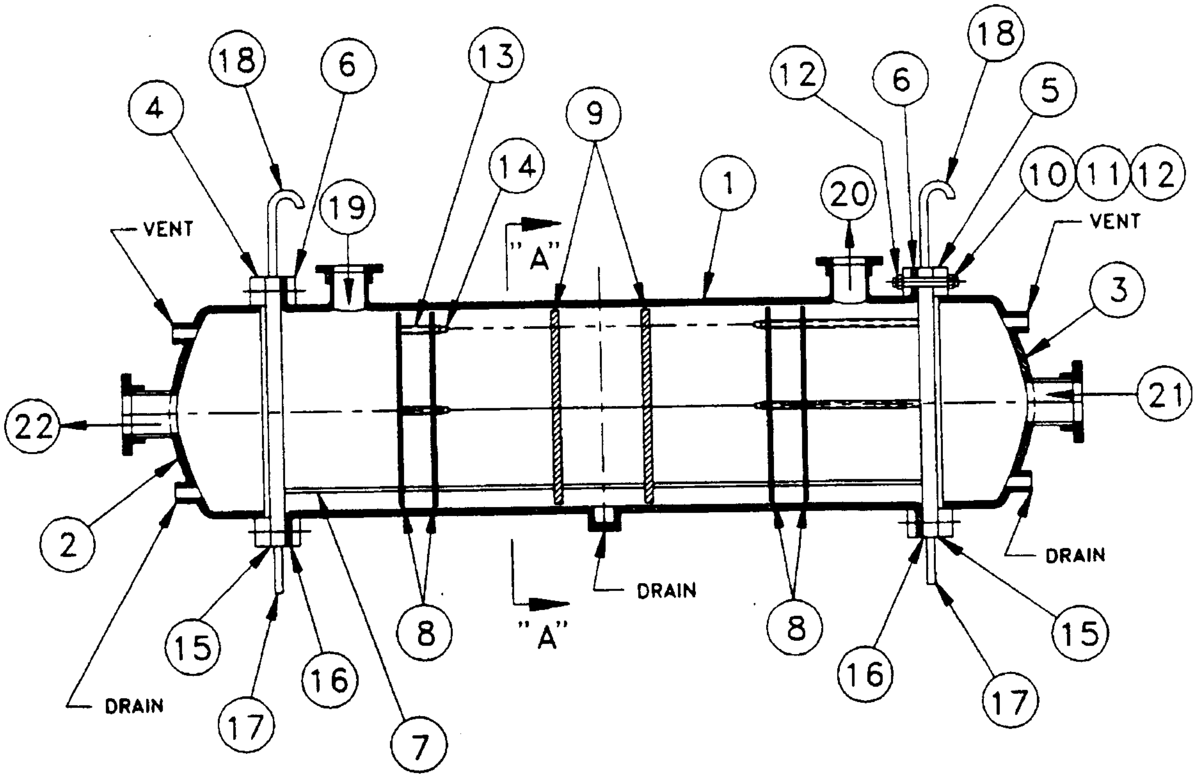
532-2.5.1 The circulating pumps used in the liquid cooling system are single-stage centrifugal pumps close-coupled to an electric motor. Some older systems use a separate pump and motor joined by a flexible coupling.

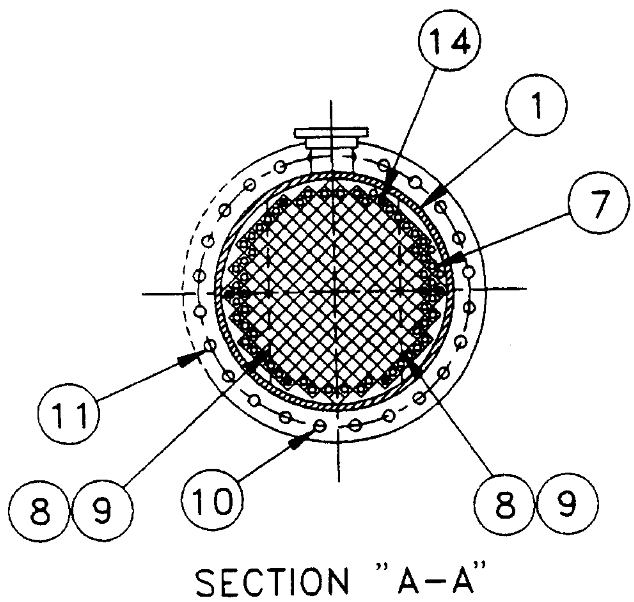
Mechanical shaft seals are used to eliminate external leakage. Some older pumps use packing glands which are allowed a specified leakage rate of three drops per minute.

532-2.5.2 Some pumps have a recirculation line that provides a water seal at pump discharge. A vent valve is provided on the top of the pump casing to remove air and insure the pump is primed. Pressure gages are provided on the pump suction and discharge to check operation of the pump.

532-2.6 HEAT EXCHANGERS

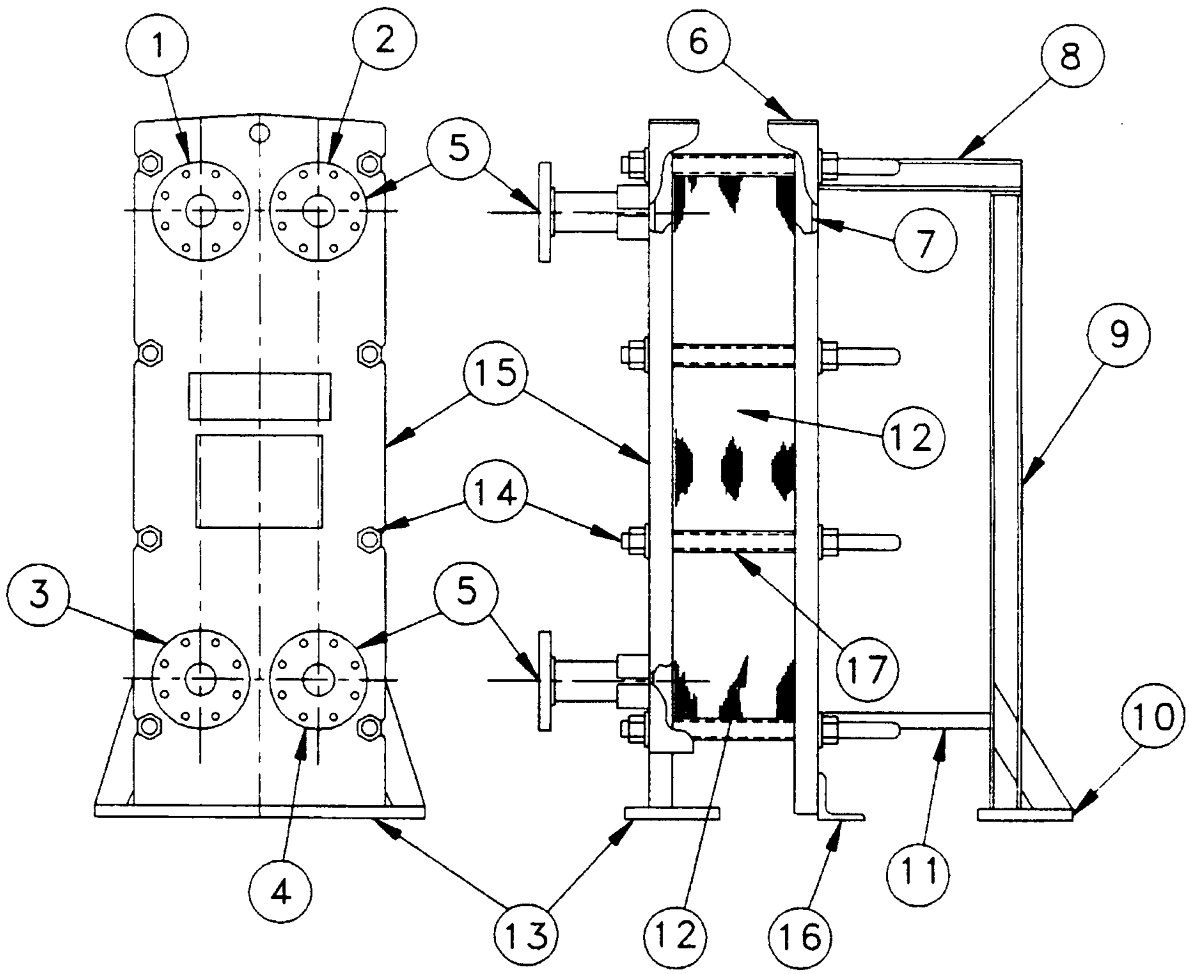
532-2.6.1 The seawater to demineralized water and chilled water to demineralized water heat exchangers are either shell-and-tube or plate type units. A seawater shell-and-tube heat exchanger is illustrated in Figure 532-2-7 while the plate heat exchanger is shown in Figure 532-2-8.





PIECE NO.	NAME
1	SHELL
2	FRONT HEAD
3	REAR HEAD
4	FRONT TUBE SHEET
5	REAR TUBE SHEET
6	STIFFENING RING
7	TUBES
8	BAFFLES
9	TUBE SUPPORT PLATE
10	STUD BOLT
11	STUD BOLT
12	NUTS FOR 10 & 11
13	TIE ROD SPACER
14	TIE ROD
15	GASKET
16	GASKET
17	TELLTALE DRAIN
18	TELLTALE VENT
19	SECONDARY COOLANT IN
20	SECONDARY COOLANT OUT
21	PRELIMINARY COOLANT IN
22	PRELIMINARY COOLANT OUT

Figure 532-2-7 Shell and Tube Seawater Heat Exchanger



PIECE NO.	NAME
1	SECONDARY COOLANT IN
2	PRIMARY COOLANT OUT
3	SECONDARY COOLANT OUT
4	PRIMARY COOLANT IN
5	NOZZLES
6	SHROUD
7	MOVEABLE FRAME
8	UPPER GUIDE BAR
9	GUIDE BAR SUPPORT
10	SUPPORT BASE PLATE
11	LOWER GUIDE BAR
12	PLATE PACK
13	BASE PLATE
14	TIGHTENING BOLT ASSEMBLY
15	STATIONARY FRAME
16	MOVEABLE FOOT PLATE
17	SPACER

Figure 532-2-8 Plate Heat Exchanger

532-2.6.2 In the shell and tube heat exchanger, the seawater or chilled water flows through the tubes, and the fluid to be cooled (demineralized water) circulates through the shell in the opposite direction.

532-2.6.3 Vent and drain connections are provided for venting trapped air and draining water from the primary and secondary portions of the heat exchanger. Temperature and pressure gages may be provided in the inlet and outlet piping to check performance of the heat exchanger.

532-2.6.4 Most seawater to demineralized water shell and tube heat exchangers use double tube sheet construction in lieu of normal single tube sheets. These units have an inner and outer tube sheet, with a void space between, at each end of the heat exchanger. The void space has an unvalved telltale drain and vent line to detect leakage occurring at the tube joints. This assists in preventing contamination of the demineralized water by seawater or loss of demineralized water due to tube joint leakage. Telltale drain and vent lines should not be confused with heat exchanger endbell or water box drain or vent valves.

532-2.6.5 Plate heat exchangers (PHE) are constructed of gasketed metal (Titanium) plates supported by a rigid frame. The primary and secondary fluids flow through separate nozzles and across the plate pack in a cross flow arrangement. Flow paths alternate and are determined by each plate's gasket configuration as illustrated in Figure 532-2-9. Plate surfaces are corrugated in a herringbone pattern inducing fluid turbulence and increased heat transfer. Gasket void sections are provided which act as ″tell tale″ drains indicating a gasket is leaking and requires replacement. It is important to note that only a hole in a plate will cause contamination of demineralized water by seawater, and that leakage of seawater or demineralized water gasket will not cause contamination. Temperature and pressure gages are provided on the inlet and outlet connections to monitor heat exchanger performance.

532-2.6.6 The heat exchangers in the demineralized water cooling system that cool the electronic equipment are either liquid-to-air or coolant jacket type heat exchangers. The liquid-to-air heat exchangers are mounted inside cabinets containing the heat-producing components. A blower circulates the air across the heat exchanger and to the heat source in an airtight environment. For the coolant jacket type heat exchanger, demineralized water is circulated through an integral water jacket around a large heat-producing component such as a power amplifier tube.

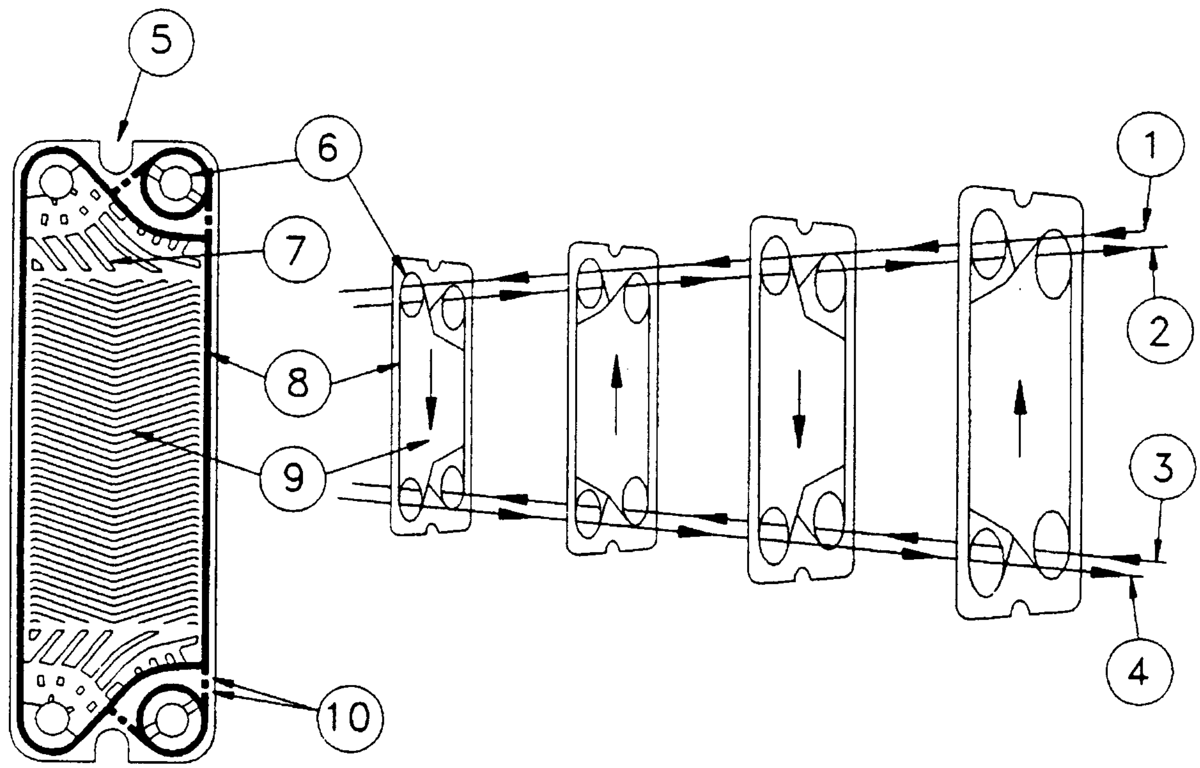
532-2.7 STRAINERS AND FILTERS

532-2.7.1 GENERAL. Strainers are used in the seawater cooling system to remove debris and prevent clogging of the tubes or passages in the seawater to demineralized water heat exchanger. Strainers are sometimes also used in the demineralized water system. Mesh size used for seawater is 1/8″ in tube and shell heat exchanger installations. For plate heat exchanger installation, a mesh size of 1/16″ is required.

532-2.7.2 Y-TYPE STRAINER. The y-type strainer contains a single body housing a wire mesh basket. A drain connection is provided at the bottom of the body to remove accumulated debris. The basket may be removed for periodic cleaning, or a blowdown valve may be provided to simply wash the basket clean with water flow.

532-2.7.3 DUPLEX BASKET STRAINER. The duplex basket strainer, illustrated in Figure 532-2-10, consists of two wire mesh baskets installed in parallel. A plug valve is used to alternate between the baskets so the idle basket can be removed for cleaning.

532-2.7.4 FILTERS. Fine mesh paper or metal filter media are used to provide demineralized water filtration to 20-30 microns.



PIECE NO.	NAME
1	SECONDARY COOLANT IN
2	PRIMARY COOLANT OUT
3	PRIMARY COOLANT IN
4	SECONDARY COOLANT OUT
5	GUIDE BAR ALIGNMENT NOTCH
6	PORTS
7	FLOW DISTRIBUTORS/DIRECTORS
8	GASKET
9	HERRINGBONE CORRUGATED SURFACE
10	GASKET VOIDS (TELLTALE DRAINS)

Figure 532-2-9 PHE Plate and Flow Arrangement

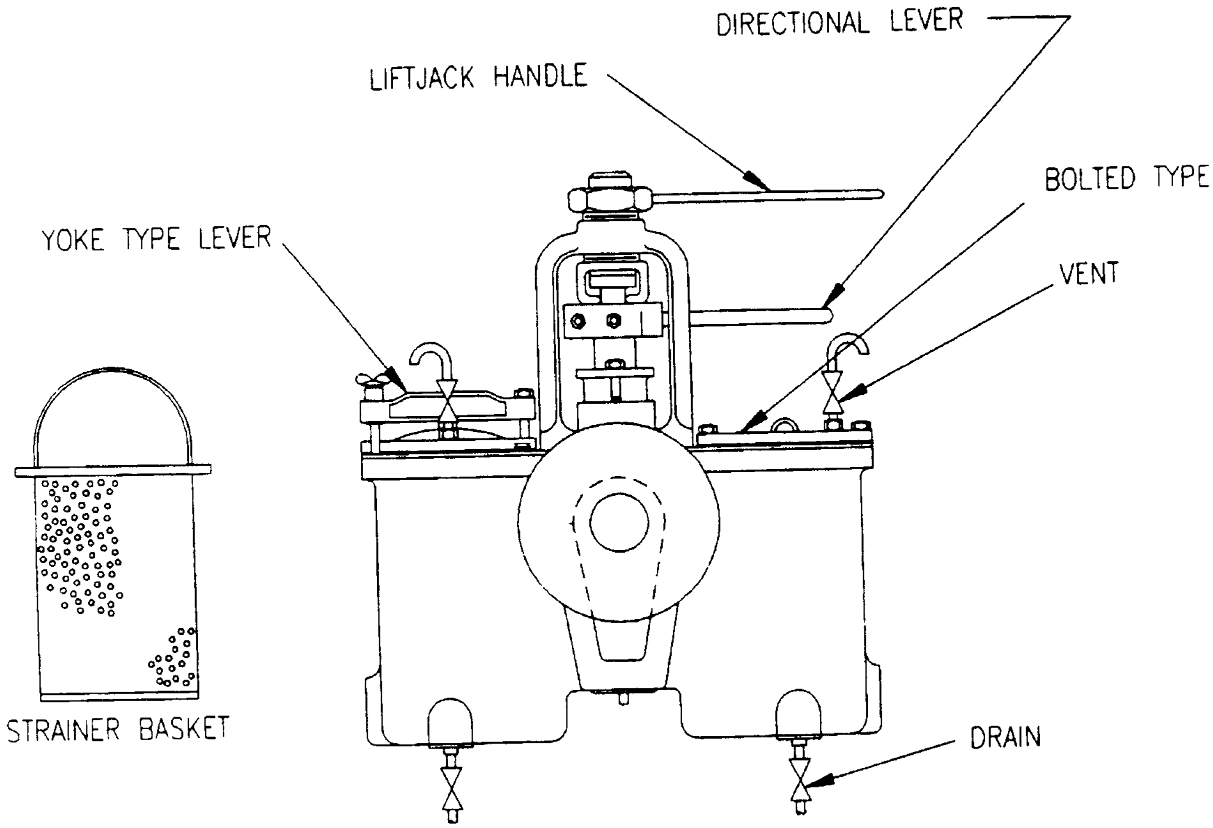


Figure 532-2-10 Duplex Strainer

532-2.8 FLOW AND PRESSURE REGULATORS

532-2.8.1 Flow and pressure regulators are used in seawater cooling systems to reduce excess available pressure from the firemain supply to an acceptable level and in multiple branch demineralized water cooling systems to distribute the required amount of cooling water to each of the electronics units. The flow and pressure regulator device may be of various designs; an orifice plate, pressure reducing valve, Cascading Orifice Restrictive Device (CORD) or constant flow-regulating fitting. The flow/pressure regulator device also prevents contamination of the demineralized water system with seawater, should tube failure occur in the seawater to demineralized water heat exchanger, when it is installed upstream of the heat exchanger.

532-2.8.2 An orifice plate consists of a thin metal plate inserted between two flanges in the pipe. The diameter of the hole drilled through the plate, and the associated pressure drop, determine the flow rate of water. Orifice plates cannot compensate for variable inlet pressures.

532-2.8.3 Pressure reducing valves, installed in the Auxiliary Seawater Cooling System, are designed to maintain a constant discharge pressure when subjected to a variable inlet pressure. As a direct result fluid flow is automatically controlled.

532-2.8.4 The Cascading Orifice Restrictive Device (CORD) is installed in seawater systems and constructed with perforated plates stacked closely together in a flanged cylindrical housing. The diameter and quantity of perforations in the internal plates and the associated pressure drop governs the rate of flow. The quantity of plates and holes assures minimum change in stream velocity with a reduction in flow generated noise. CORDS, like orifice plates, cannot compensate for variable inlet pressures.

532-2.8.5 The constant-flow regulating fitting, illustrated in Figure 532-2-6, is a variable orifice type device used extensively in demineralized water and chilled water systems, but rarely in seawater systems. It maintains a constant-flow rate with changes in inlet pressure. As pressure increases the diaphragm is squeezed into a new shape to maintain the rated flow. In demineralized water systems, fittings are installed in the upstream or downstream piping to each electronics component. Use in seawater service is cautioned and extreme seawater filtration is necessary (1/32″ mesh maximum). Use of monel trim is also necessary.

532-2.8.6 Orifices and CORDS are also installed downstream of the seawater heat exchanger close to the overboard discharge connection to prevent vacuum conditions at the heat exchanger. The regulator also insures full internal submergence of the heat exchanger, as the water pressure decreases through the regulator.

532-2.8.7 Deposits or particles that lodge in the flow regulator restrict the water flow and cause heat exchanger overheating. Flow regulator cleaning is required.

532-2.8.8 Seawater erosion of a flow regulator increases the water flow to the heat exchanger. This condition causes erosion of a heat exchanger tubes because of high water velocity. Flow regulator inspection and replacement is required.

532-2.9 FLOW SWITCH

532-2.9.1 Flow switches are monitoring devices used to indicate low or high flow conditions.

532-2.9.2 Flow switches may be ″in-line″ type using a spring loaded shuttle and rod assembly (Figure 532-2-11). This design is sensitive to clogging by any debris in the water and is not recommended for use in seawater systems.

532-2.9.3 Flow switches may also be remote operating via pressure taps on either side of a restrictive device Figure 532-2-12. The pressure on either side is compared by a diaphragm assembly, and the switch is set to a value which represents a high or low flow condition.

532-2.10 FLOW METER

532-2.10.1 A flow meter is used to indicate the flow rate of cooling water and is usually installed in the demineralized water system with a valved bypass.

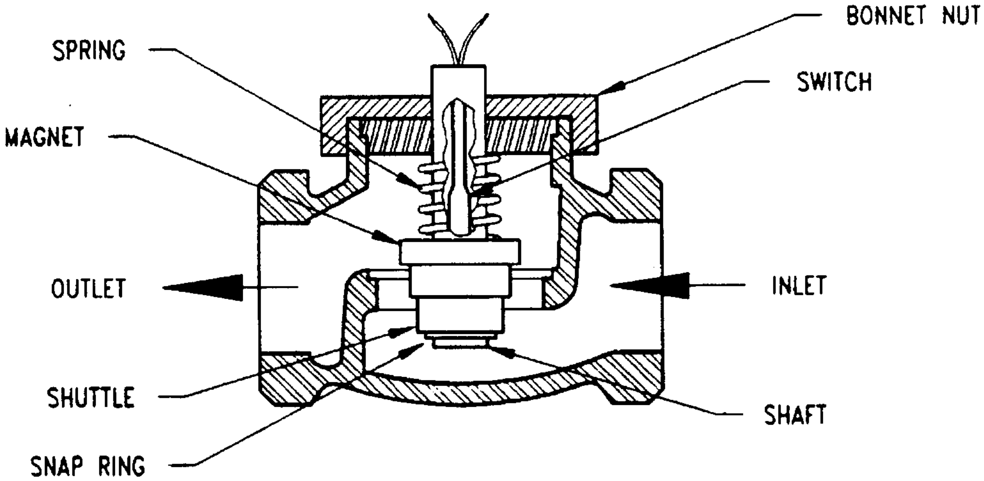


Figure 532-2-11 In-Line Flow Switch

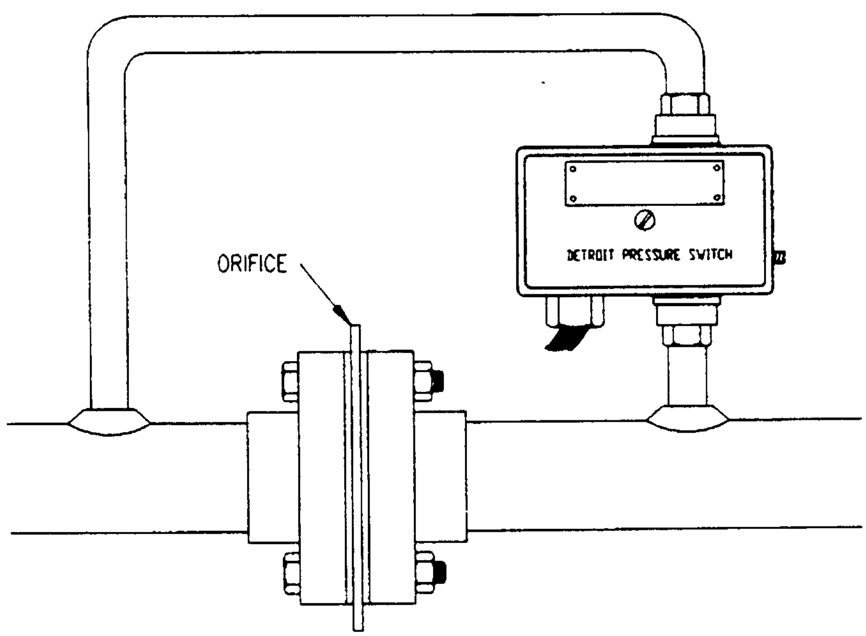


Figure 532-2-12 Orifice Flow Switch

532-2.10.2 A rotameter flow meter (Figure 532-2-13) consists of a float or indicator against a graduated flow rate scale. The position of the float with respect to the scale on the tube directly indicates the rate of cooling water flow.

532-2.10.3 A venturi flow meter (Figure 532-2-14) consists of a short tube with tapering construction in the middle that causes an increase in the velocity of a fluid and a corresponding decrease in fluid pressure. The low pressure at the venturi throat is measured and compared to the high pressure at the venturi inlet. The differential of these two pressures is normally read on a differential pressure gauge that has been calibrated for flow rate in gallons per minute (GPM). The only acceptable venturi tube construction material for seawater service is monel.

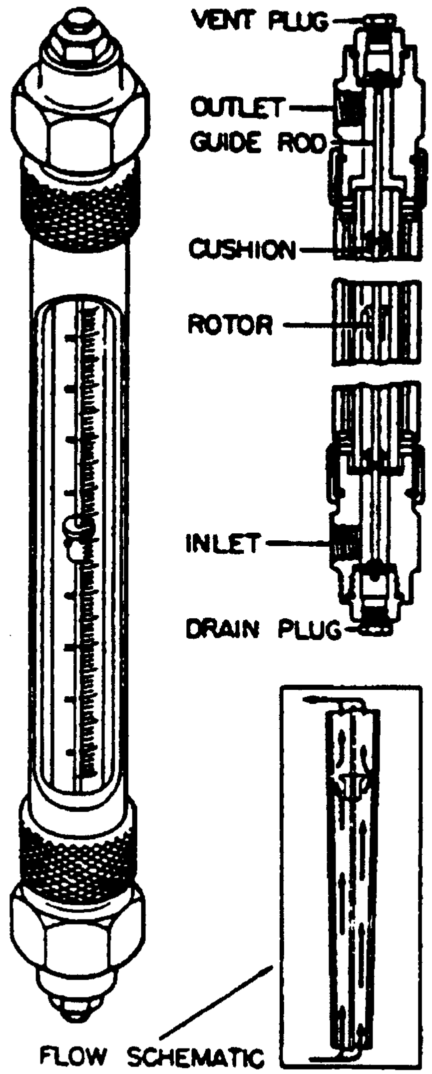


Figure 532-2-13 Rotameter

532-2.10.4 An orifice plate flow meter (Figure 532-2-15) consists of an in-line orifice plate. Inlet and outlet pressure is measured and compared by a gage calibrated for flow rate in (GPM). Orifice plate material is monel for seawater service.

532-2.11 TEMPERATURE REGULATING VALVE

532-2.11.1 The temperature-regulating valve is used to regulate the amount of cooling water flow through or around a heat exchanger to maintain a desired water temperature.

532-2.11.2 A two-way remote sensing valve is illustrated in Figure 532-2-16, a three-way remote sensing valve is shown in Figure 532-2-17, and a three-way internal sensing valve in Figure 532-2-18.

532-2.11.3 The two-way valve shown in Figure 532-2-3, Figure 532-2-4 and Figure 532-2-5 is used to regulate the supply of chilled water to maintain a constant temperature (for example: 92°F ± 3°F), of the demineralized water delivered to the electronic equipment. As the temperature of the demineralized water exceeds a preset temperature, the temperature regulating valve opens to allow a flow of chilled water through the heat exchanger. The valve will continue to open until the demineralized water temperature is at the preset value. When the temperature decreases beyond the set point, the valve will close.

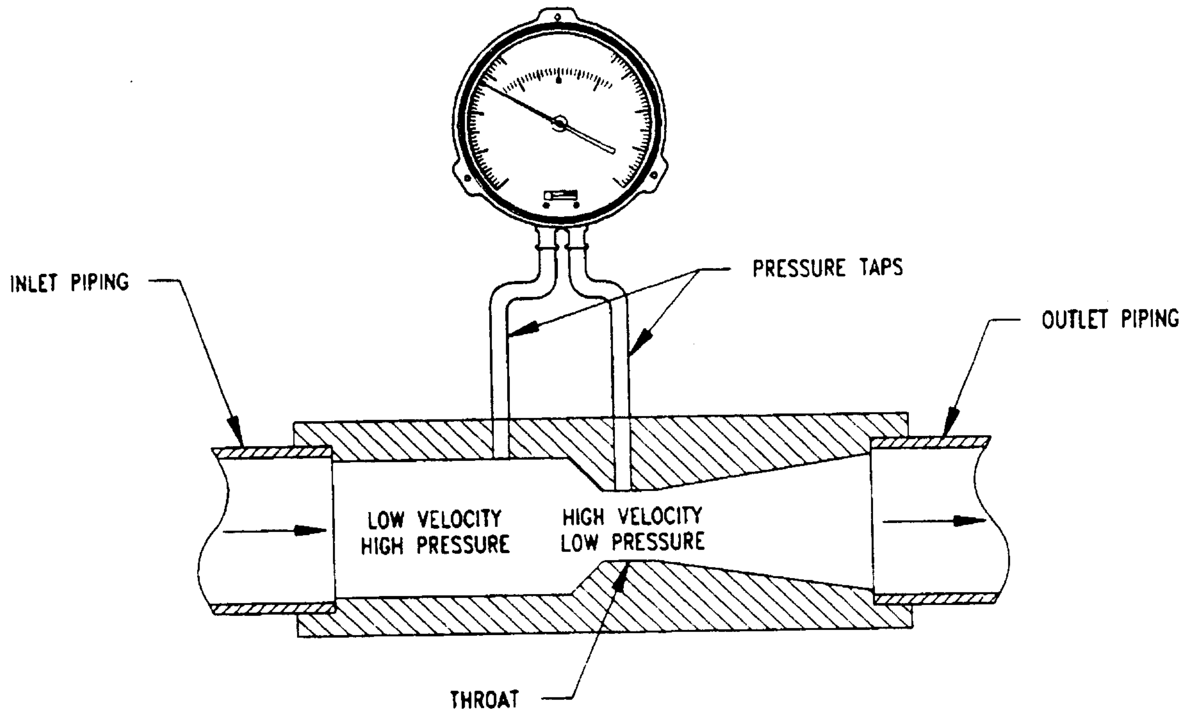


Figure 532-2-14 Venturi Flow Meter Fitting

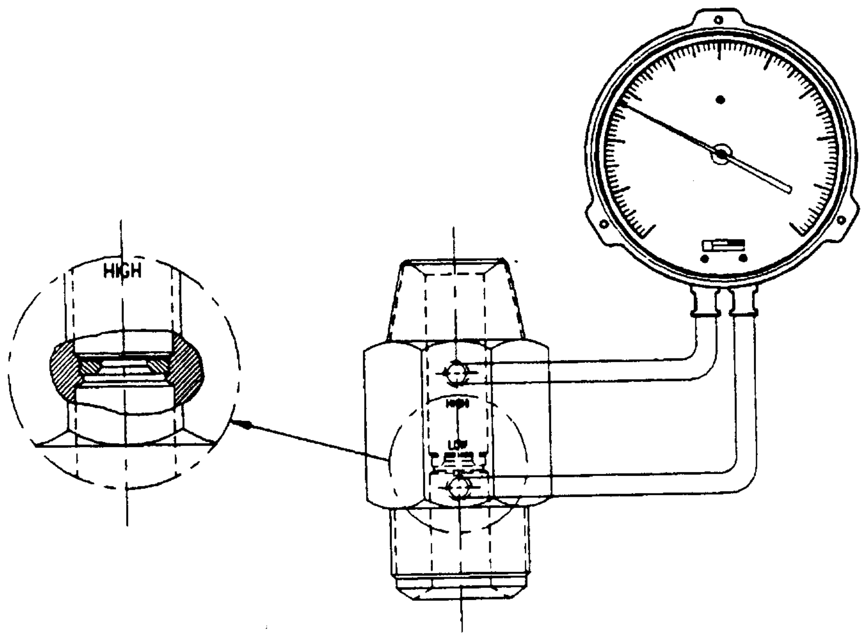


Figure 532-2-15 Venturi Flow Meter Fitting

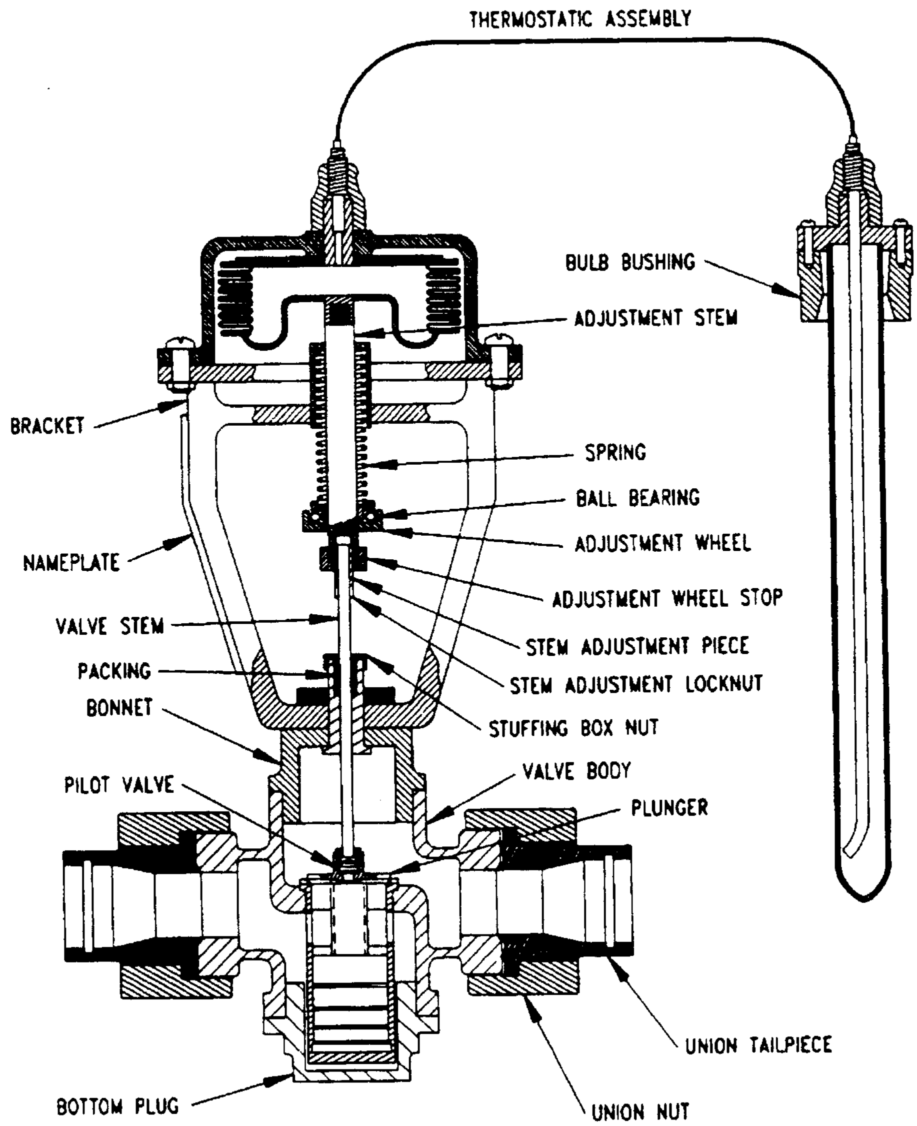


Figure 532-2-16 Two-Way Temperature Regulating Valve

532-2.11.4 Figure 532-2-1, Figure 532-2-2, Figure 532-2-3, and Figure 532-2-4 show two arrangements of a three-way remote sensing valve used to regulate the flow of demineralized water where the primary system is seawater. As the temperature of the demineralized water decreases below a preset temperature (for example: 85°F ± 5°F), the temperature-regulating valve opens to allow a flow of demineralized water to bypass the heat exchanger. The valve will continue to open until the flow is established that returns the demineralized water temperature to the preset value. When the temperature exceeds the set point, the valve will close.

532-2.11.5 Three-way internal sensing temperature-regulating valves are used in piping arrangements as illustrated in Figure 532-2-1, Figure 532-2-2, Figure 532-2-3, and Figure 532-2-4. These valves achieve identical results as the remote sensing type, however, are self contained and do not require the thermostatic bulb assembly. The element is preset by the manufacturer and does not require adjustments during service, however, in the event of a casualty, a manual override bypass is provided for maximum cooling.

532-2.12 EXPANSION TANK

CAUTION

An air-pressurized system must be vented before attempting repairs or maintenance.

532-2.12.1 The expansion tank compensates for changes in volume of the demineralized water, maintains a positive head throughout the system, vents air from the system, and provides a source of make-up water in the event of a system leak. The tank may be either a gravity tank or a compression tank.

532-2.12.2 When a gravity tank is used, the location is above the highest point in the demineralized water system. This ensures a higher pressure at connection of tank to the suction side of the circulating pump to allow a flow of water from the tank into the system when make-up water is required. The tank is provided with a sight glass to check the level of water in the tank. A vent connection is located on the top of the tank to release air and prevent pressure build-up in the system. A valve and funnel connection are located on top of the tank for filling the system with distilled water. The gravity tank is equipped with a valved drain and a low level switch which activates a low level alarm.

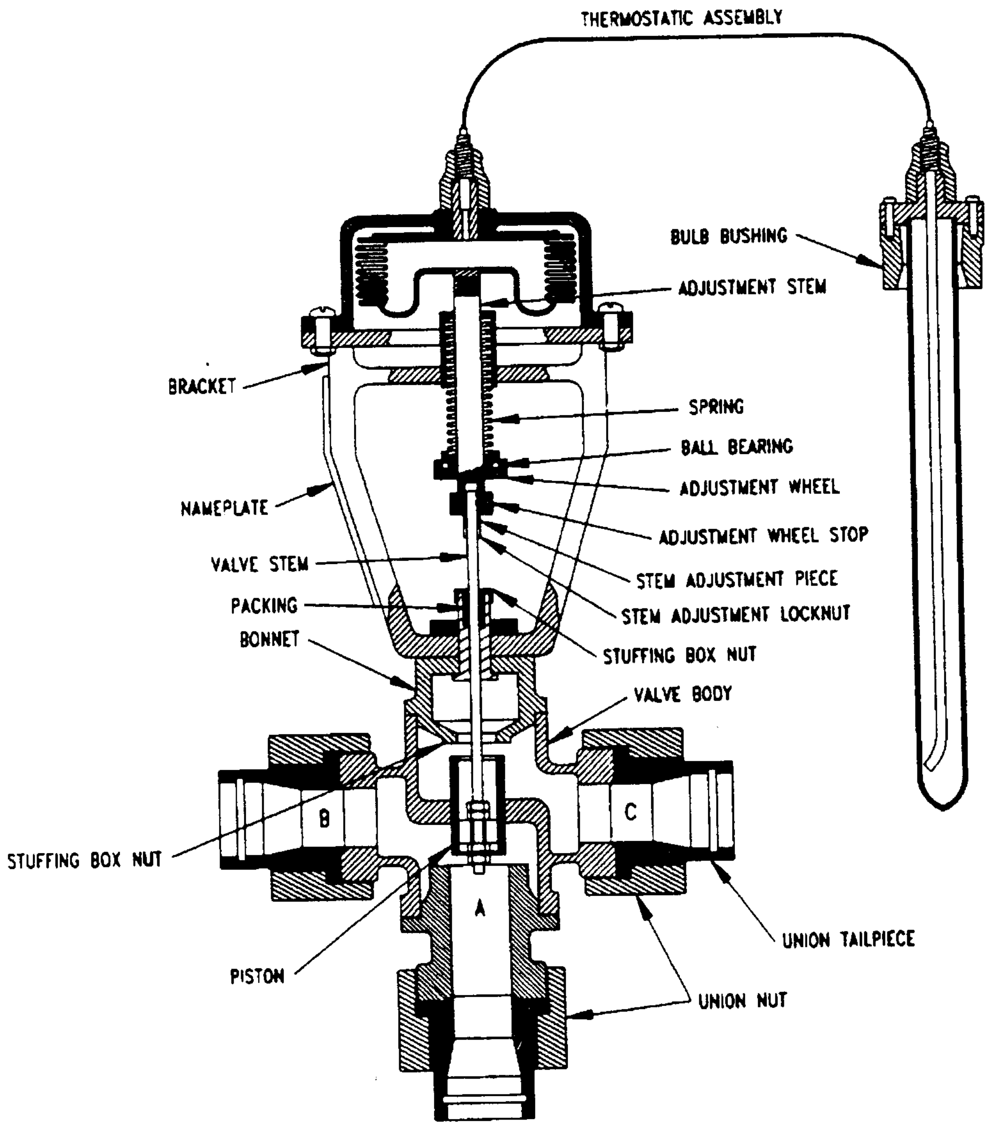
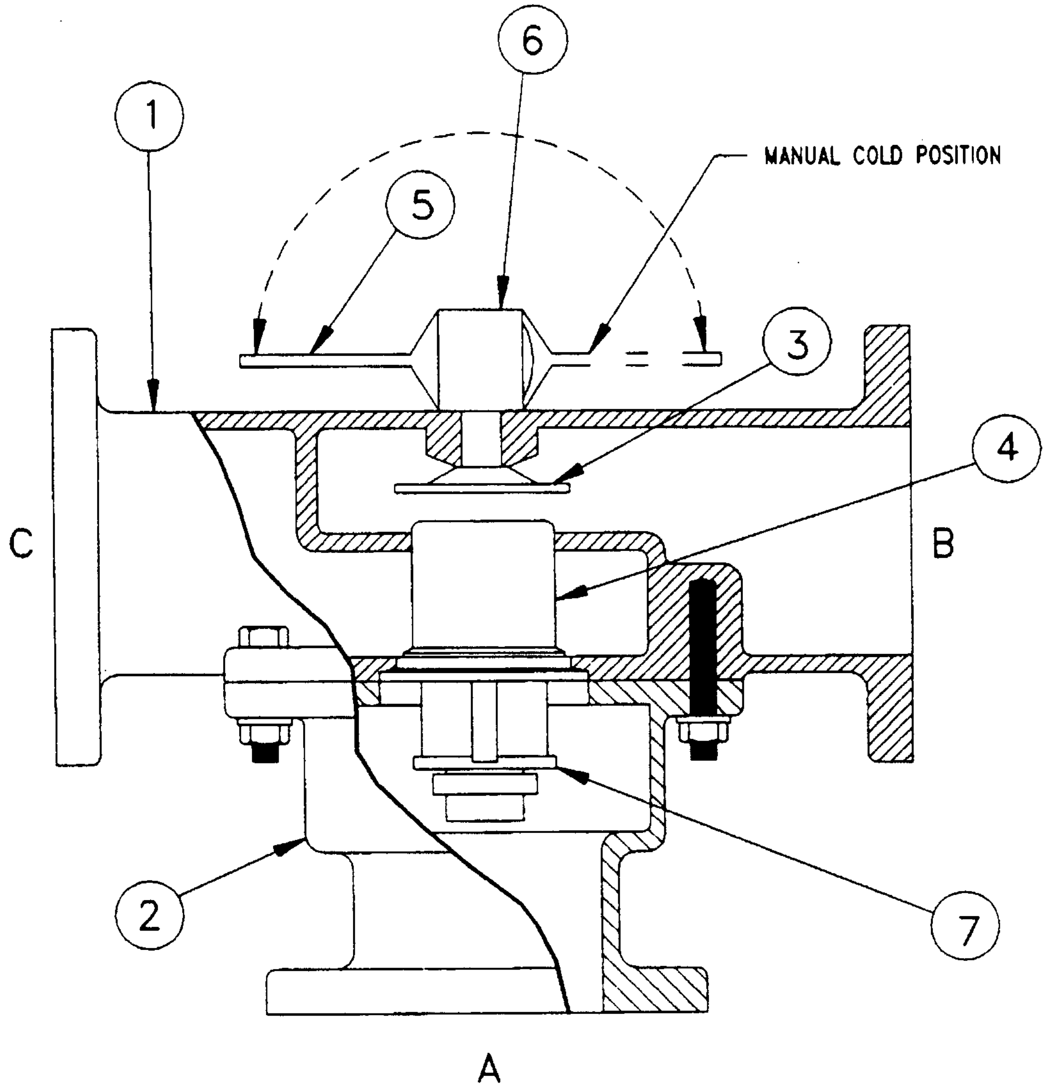


Figure 532-2-17 Three-Way Temperature Regulating Valve



PIECE NO.	NAME
1	UPPER HOUSING ASSEMBLY
2	LOWER HOUSING ASSEMBLY
3	SEAT
4	SLEEVE
5	LEVER
6	SPRING ASSEMBLY
7	ELEMENT ASSEMBLY

Figure 532-2-18 Internal Sensing Three-Way Temperature Regulating Valve

532-2.12.3 When a compression tank is used, it is usually located near the circulating pump and is charged with compressed air to the appropriate pressure. The compressed air maintains the static pressure in the tank. The vent connection is valved and provided with a hose valve to serve as an air charging connection. A relief valve is provided to protect the tank and demineralized water system from over-pressurization. The compression tank is equipped with a low level switch which activates a low level alarm. Some compression tanks are equipped with a high level switch and an extreme low level switch in addition to a low level switch. Compression tanks are also provided with a sight glass to check the tank water level, a valved funnel fill connection and a valved drain.

532-2.13 AUTOMATIC AIR VENTS

532-2.13.1 Automatic air vents (Figure 532-2-19) are sometimes used in the demineralized water system. The vent automatically removes entrapped air in the system thereby preventing a reduction in flow. Venting of air also ensures that air does not dissolve into the water, which will increase conductivity and copper oxide formation.

532-2.14 DEMINERALIZER

532-2.14.1 A small percentage of the demineralized water system is recirculated from the circulating pump discharge through the demineralizer, as shown in Figure 532-2-20, to maintain a high purity of the coolant.

532-2.14.2 A flow-regulating device, such as an orifice or a valve, maintains the required rate of coolant flow. The distilled water is purified by two types of cartridges installed in series. The oxygen removal cartridge is composed of anion resins which are designed to remove oxygen from the water. The mixed bed cartridge is filled with cation and anion resins designed to remove metallic, hard water ions, and carbon dioxide. A submicron filter is used to remove small particles from the distilled water, and to prevent any cartridge resin beads from entering the system if the cartridge is damaged.

532-2.14.3 A flow switch is located downstream of the submicron filter. The flow switch actuates an alarm when the flow rate through the demineralizer has decreased below a preset level, indicating that the filter element is clogged.

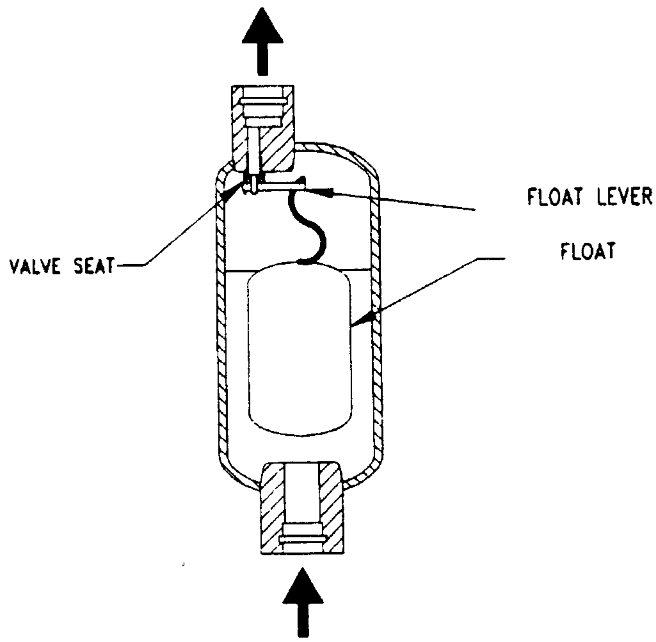


Figure 532-2-19 Automatic Air Vent Valve

532-2.14.4 A purity cell measures the purity of the water as it enters the demineralizer. A second purity cell is used to measure the purity of the water as it leaves the demineralizer. Output purity should be higher than the inlet purity, which indicates the demineralizer cartridges are purifying incoming water.

532-2.14.5 The purity cell consists of two electrodes immersed in the water flow path. The electrodes measure the resistivity of the distilled water which varies with the amount of dissolved ionized salts. The resistance and corresponding meter indication vary both with ionized salt concentration and the temperature of the water flowing through the cell. The temperature effect is canceled by a temperature-co mpensation circuit.

532-2.14.6 The water resistivity is compared to a preset value of cell resistance to actuate an alarm circuit when the purity of the water drops below the preset level. In addition, a purity meter is provided to take direct readings of the water purity at the inlet and outlet of the demineralizer. The meter may read resistivity or conductivity.

532-2.14.7 The demineralizer is capable of maintaining the water at the following specifications:

a. Resistivity - 0.5 megohm/cm minimum at 77°F

b. Conductivity - 2 micromho/cm maximum at 77°F

c. Oxygen content - 0.1 ppm by weight

d. Mechanical Filtration - 0.5 micrometer (micron) absolute

532-2.14.8 The impurities found in distilled water usually are in the form of dissolved solids. The amount of dissolved solids in distilled water can be measured by measuring the conductivity (micromhos/cm) or resistivity (megohms/cm) of the distilled water.

532-2.14.9 The purity meter on the demineralizer measures the resistivity of the water in megohms/cm. The resistivity can be converted to conductivity by taking the reciprocal of the resistivity. Likewise, the reciprocal of the conductivity is equal to the resistivity. Table 532-2-2 is provided for ready reference.

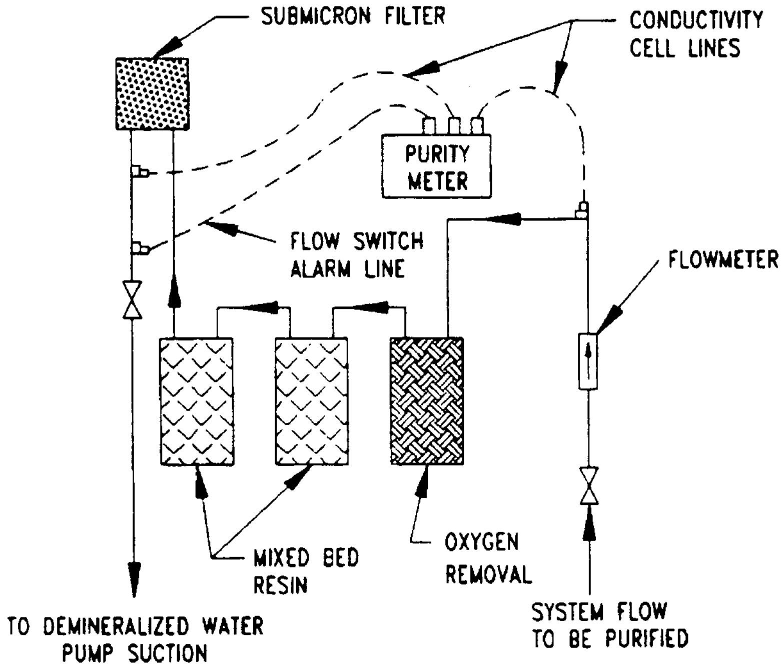


Figure 532-2-20 Demineralizer Flow Path

Table 532-2-2 RESISTIVITY AND CONDUCTIVITY CONVERSION

Resistivity (megohms/cm)	Conductivity (micromhos/cm)	Chlorides (epm)
10.0	0.1	0.00
2.0	0.5	0.00
1.0	1.0	0.01
0.5	2.0	0.01
0.1	10.0	0.07

532-2.15 GAGES AND SWITCHES

532-2.15.1 In addition to the instrumentation discussed previously in Section 2, pressure and temperature gages and switches are used to provide remote monitoring and warning of cooling system operation and impending faults. Typical applications would be:

a. Pressure of water in the demineralized water system.

b. Temperature of the demineralized water supplied to the electronics.

c. Water level in the expansion tank.

532-2.15.2 The devices might be connected to remote indicators, to visual or audible alarms, or to interlocks which de-energize the electronic equipment and pumping equipment.

532-2.15.3 Gage calibration guidance. Gages that monitor the following parameters are considered critical and shall be calibrated every 18 months (pressure bourdon tube type) or 36 months (bimetallic temperature type):

a. Demineralized water pump discharge pressure gage.

b. Demineralized water supply temperature gage.

c. Electronics component return temperature gages.

d. Chilled water supply pressure gage.

e. Seawater supply pressure gage and reducer outlet pressure gage.

532-2.16 VALVES

532-2.16.1 Valves are used to regulate flow, isolate flow from one area of piping to another area, and provide automatic relief from over pressurization. Table 532-2-3 is provided for ready reference.

532-2.17 FLEXIBLE HOSES

532-2.17.1 Flexible rubber hose and polytetrafluorethylene (PTFE) hose assemblies connect cooling water piping and system components, and electronic components and cabinets. Technical Manual NAVSEA S6430-AE-TED-010 contains requirements for the selection, fabrication, inspection, testing, installation and replacement of flexible hose assemblies. Frequently used maintenance requirements are summarized below.

532-2.17.2 Rubber hose assemblies have a service life of 5-1/2 or 12 years. Applicable service life is determined from criticality factor calculation in appendix 3 of the flexible hose assembly technical manual. Five years service life applies to critical application rubber hose assemblies; 12 years applies to non critical rubber hose assemblies. PTFE hose does not have a specific service life.

532-2.17.3 Flexible rubber hose assemblies are to be inspected every year in accordance with the procedures outlined in the applicable PMS MRC's.

532-2.17.4 PTFE hose assemblies are to be inspected every year. They are to be replaced upon evidence of the following conditions:

a. Tube shows signs of cracking, blistering, splitting or other failure.

b. Twenty or more external wires are broken randomly over the hose.

c. Any cut, slice, or gouge involving four or more adjacent wires.

532-2.17.5 PTFE flexible hoses require a hydrostatic test every five years. After visual inspection, the hose assembly shall be subjected to a hydrostatic test to 1-1/2 times system pressure. The hose assemblies shall be returned to service upon satisfactory completion of both visual examination and hydrostatic test.

Table 532-2-3 VALVE TYPES AND APPLICATIONS

Design	Application	Specification	Figure No.
Gate Valve	Isolation	NAVSEA STD DWG 803-2177917 (Flanged), 803-1385714 (Union End)	Figure 532-2-25
Butterfly Valve	Isolation	MIL-V-24624 (Valves, Butterfly, Isolation)	Figure 532-2-22
Globe Valve	Isolation, Flow Regulation	NAVSEA STD DWG 803-4384536 (Straight), 803-1385623 (Y-pattern), Union End	Figure 532-2-26
Ball Valve	Isolation	NAVSEA STD DWG 803-5001003 (2-Way), 803-5001004 (3-Way)	Figure 532-2-23 Figure 532-2-24
Reducing and Regulating Valve	Flow and Pressure Regulation	MIL-V-2042 (Valves, Reducing, Water Service)	Figure 532-2-27
Relief Valve	Pressure Relief	MIL-V-22549 (Valves, Relief, Air Service)	Figure 532-2-28
Swing Check Valve	Back Flow Prevention	MIL-V-1747 (Valves, Check), NAVSEA STD DWG 803-1385637 (Flanged), 803-1385721 (Union End)	Figure 532-2-21
Duplex Strainer	Filtration	MIL-S-17849 (Strainer, Sediment, Pipeline, Duplex)	Figure 532-2-9

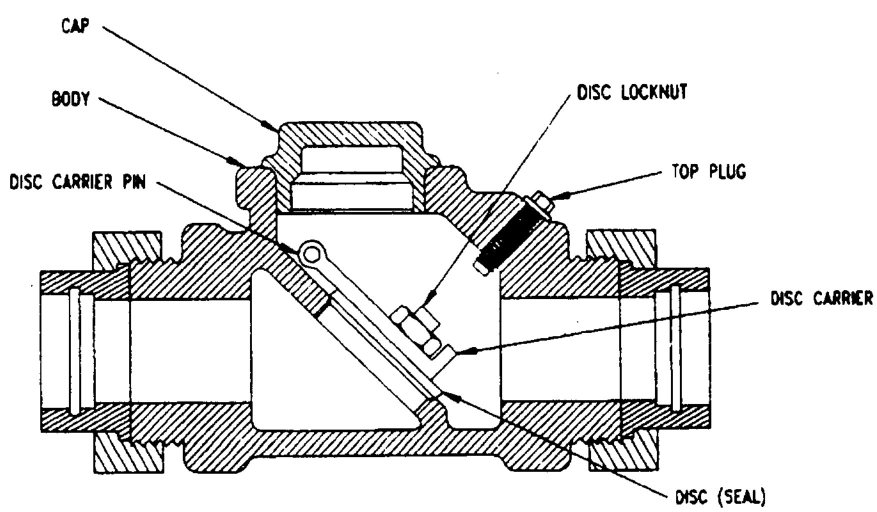


Figure 532-2-21 Swing Check Valve

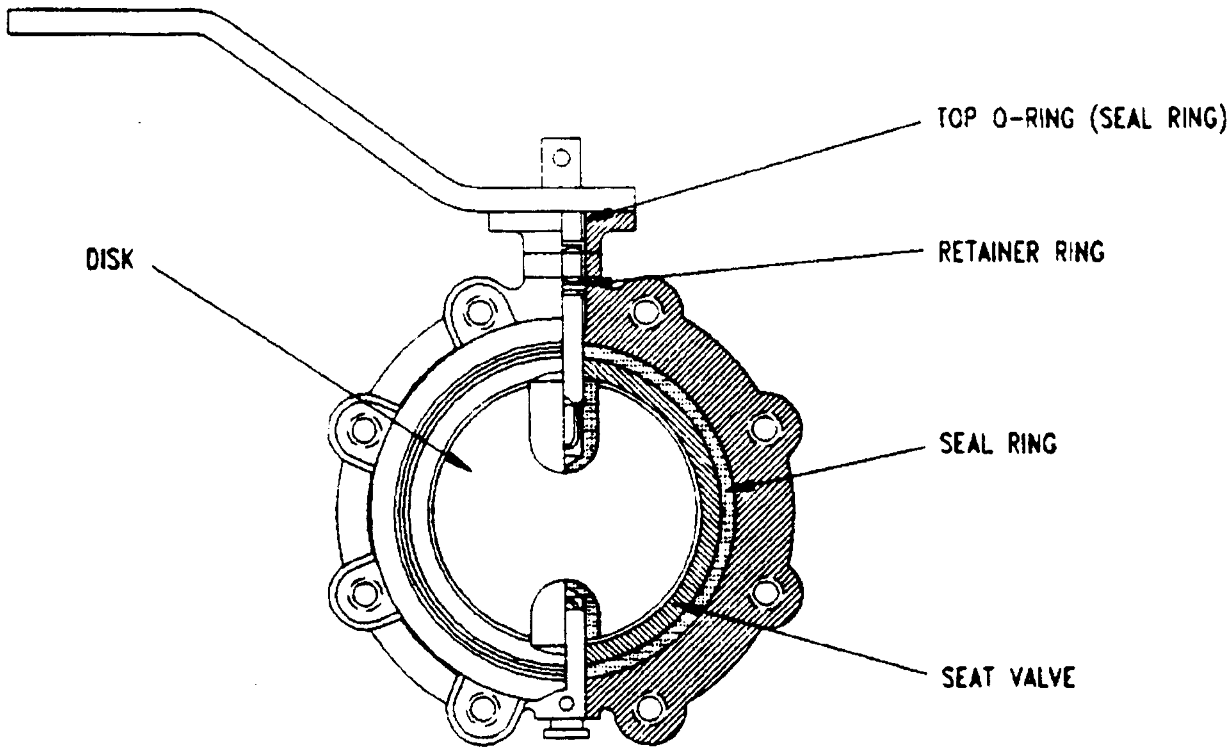


Figure 532-2-22 Butterfly Valve

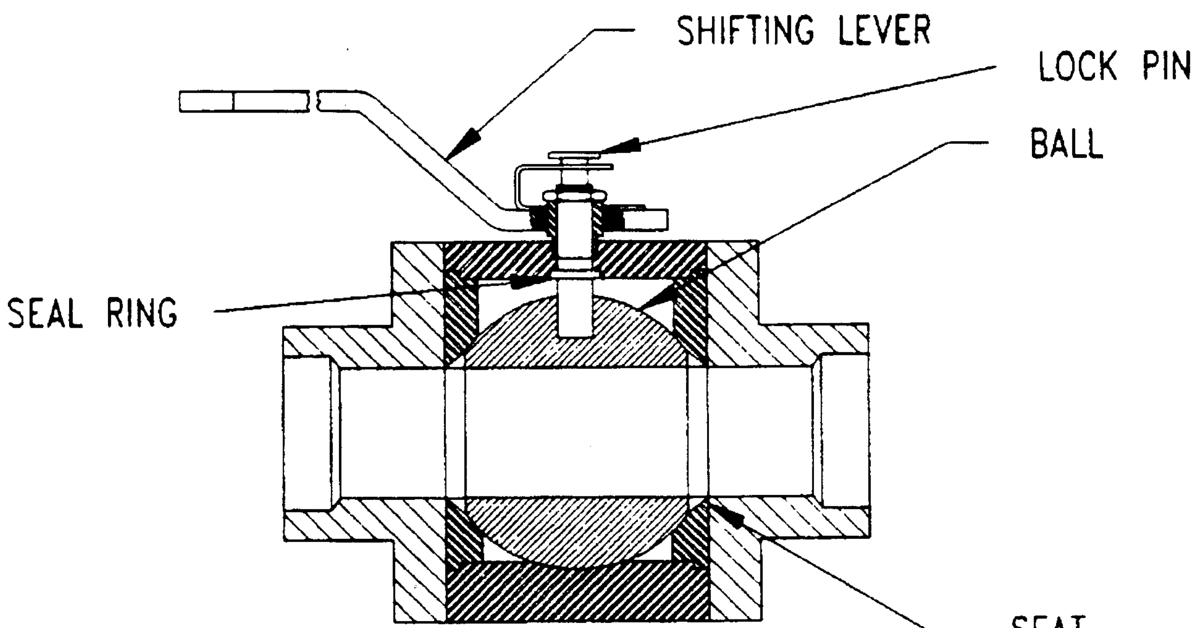


Figure 532-2-23 Two Way Ball Valve

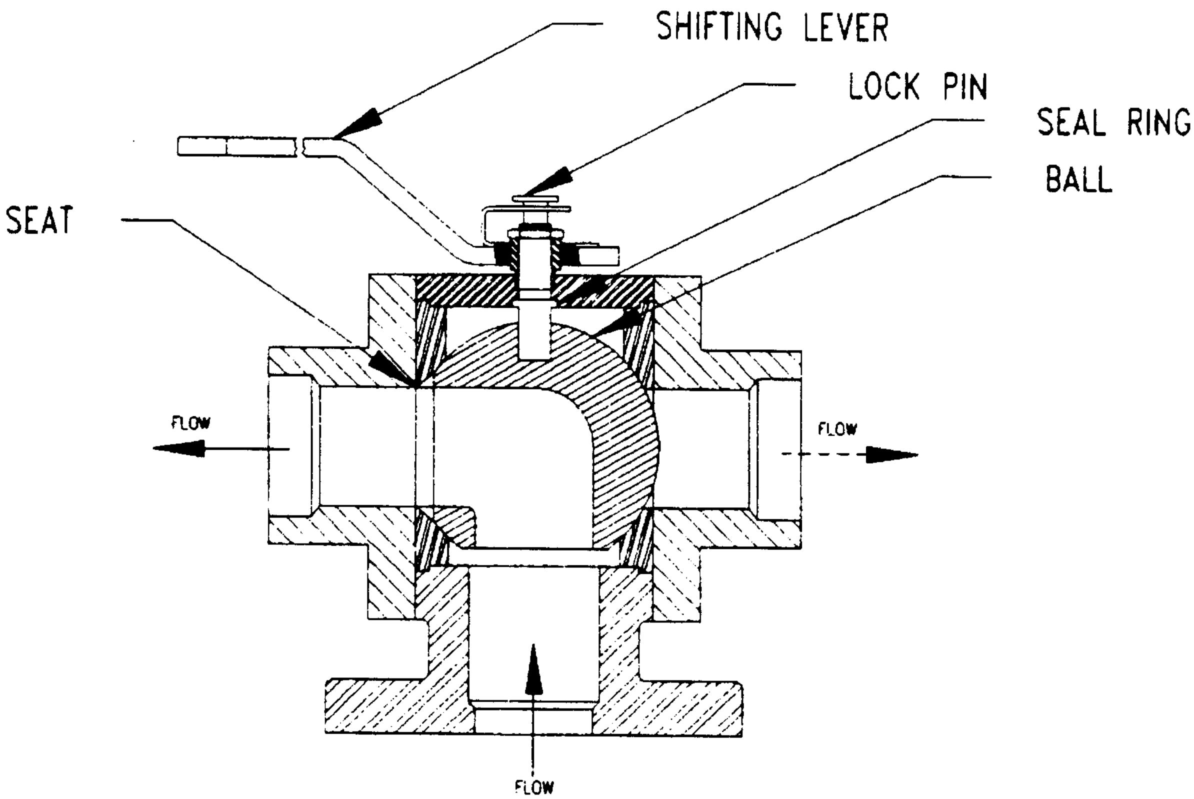


Figure 532-2-24 Three Way Ball Valve

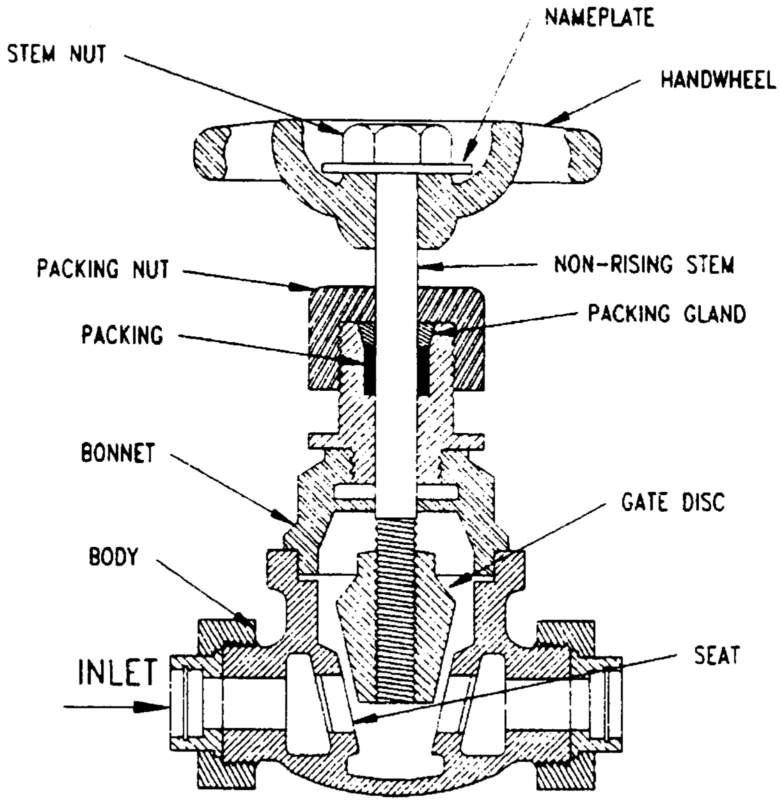


Figure 532-2-25 Gate Valve

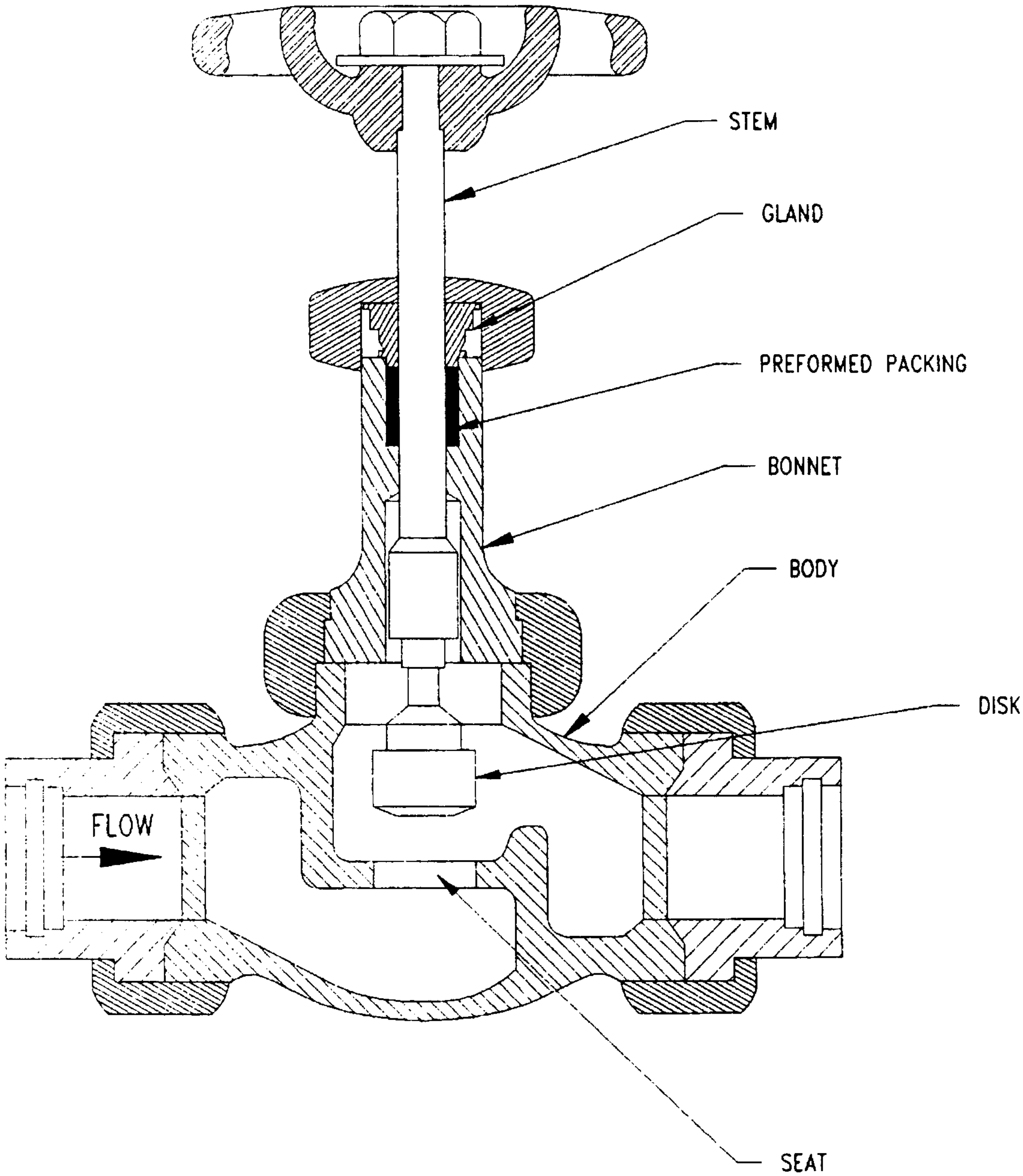


Figure 532-2-26 Globe Valve

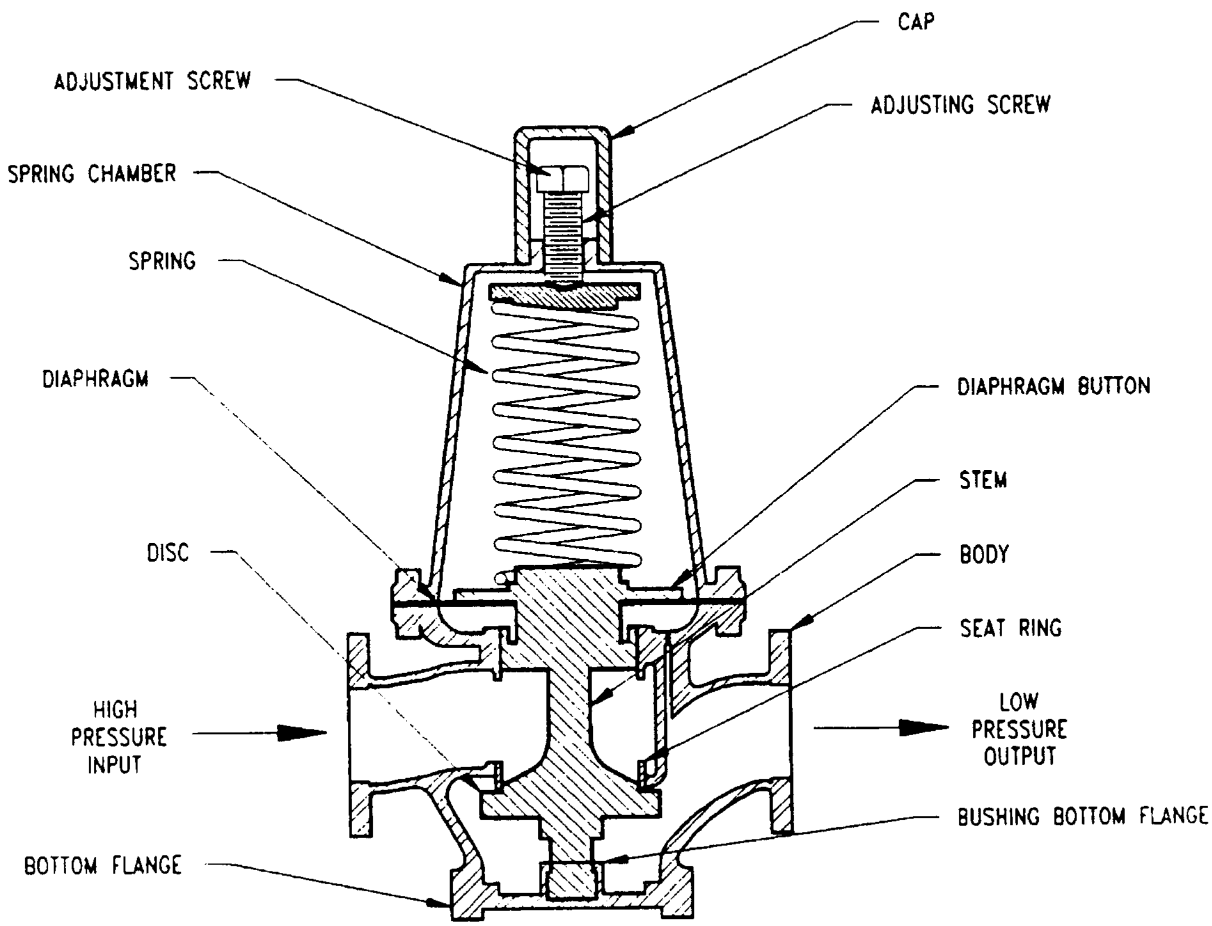


Figure 532-2-27 Pressure Regulating and Reducing Valve

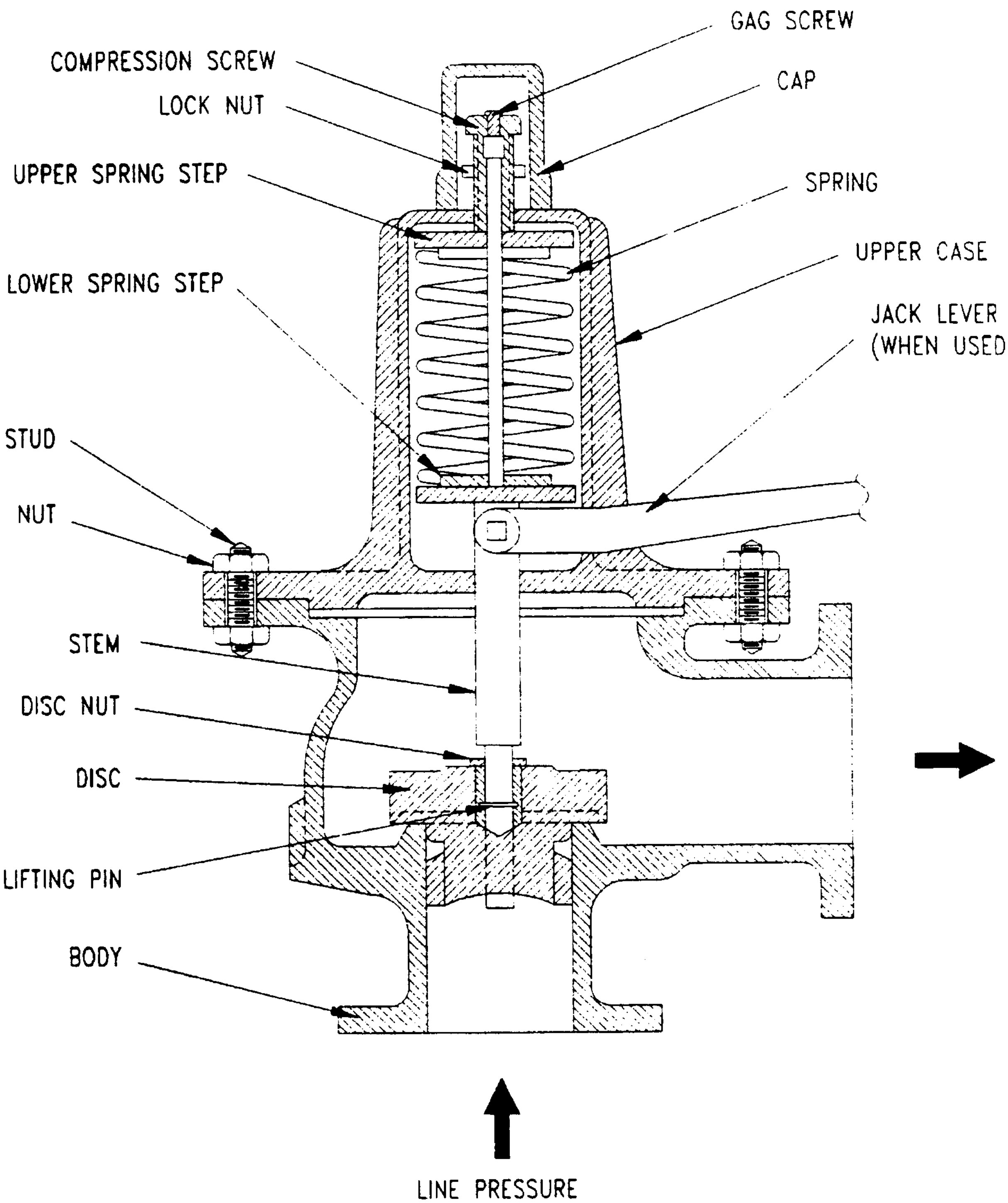


Figure 532-2-28 Relief Valve

SECTION 3.

SYSTEM AND COMPONENT OPERATION

532-3.1 INTRODUCTION

532-3.1.1 This section describes procedures for operation of the liquid cooling system for electronic equipment. Steps listed are general and do not supersede those given in system and equipment technical manuals.

532-3.2 LIGHT-OFF

532-3.2.1 Light off the demineralized water system first, in accordance with paragraph 532-3.6 before lighting off seawater or chilled water systems.

532-3.2.2 Light-off procedure begins by assuming all valves are secured and electrical circuits de-energized.

532-3.3 DEDICATED SEAWATER CIRCULATING SYSTEM

532-3.3.1 To light off the seawater circulating system, the following steps are to be taken:

1. Inspect strainer for cleanliness.
2. Open valve from sea chest to pump suction. Close drain valves on heat exchanger.
3. Open air vent until pump is primed. If a pump casing auto air vent is provided keep the cutout valves open.
4. Open all valves downstream of pump discharge valve to overboard sea chest.
5. Energize pump motor and, as discharge pressure increases, slowly open pump discharge valve.
6. Vent water boxes on heat exchanger, both inlet and outlet. If heat exchanger auto air vent is provided keep the cutout valves open.

NOTE

Only one heat exchanger is on-line with the other secured on standby

7. Check flow meter for correct indication.
8. Adjust system flow at the pressure reducing station (if applicable).

532-3.4 AUXILIARY SEAWATER SYSTEM

532-3.4.1 To light off the Auxiliary Seawater system, the following steps are to be taken.

1. Inspect seawater duplex strainer for cleanliness.
2. Open Auxiliary Seawater supply valve to system.
3. Vent all heat exchangers and high points in the piping system. Where a heat exchanger auto air vent is provided keep cutout valves open.

NOTE

Only one heat exchanger is on-line with the other secured on standby.

4. Open system discharge and overboard valves.
5. Check seawater flow at flow meter.
6. Ensure flow is directed through the reducing valve vice orifice or globe valve bypass. Adjust system flow at the pressure reducing station (if necessary).

532-3.5 CHILLED WATER SYSTEM

532-3.5.1 Check to determine if light-off procedures for the air conditioning plants were taken. To light-off chilled water system the following steps are to be taken.

1. Open chilled water supply valve to system.
2. Vent all heat exchangers and high points in the piping system.
3. Open system discharge valve.
4. Check chilled water flow or pressure through available monitoring device.
5. Check chilled water supply temperature for proper range (44°F - 45°F).

532-3.6 DEMINERALIZED WATER SYSTEM

532-3.6.1 Steps for lighting-off the demineralized water system are to be taken.

1. Check system to verify that it contains the proper amount of water. Expansion tank should show at least 1/2 to 2/3 full.
2. Open valves at pump suction, pump recirculating line, heat exchanger inlet and outlet, expansion tank, filter, and flow meter inlet and outlet.
3. Open air vent until pump is primed.
4. Energize pump motor, and as discharge pressure increases, slowly open pump discharge valve.
5. Vent all heat exchangers and high points in piping system.
6. Open demineralizer vent valves. Open inlet valve slowly. When air has been vented, close vent valves and open outlet valve.
7. Operate demineralizer until the purity meter at inlet reads below 2 micromhos/cm at 77°F. This may require considerable time depending upon system volume, initial water purity, and condition of demineralizer. Circulation time may vary from one hour after temporary shutdown to 24 hours for a newly filled system.

NOTE

If extended operation of demineralizer is required, the seawater or chilled water cooling system should be secured to prevent condensation on demineralized water system piping and components from cold water.

8. Verify alarms are not activated at IC/SM alarm panels.

532-3.7 OPERATIONAL CHECKS

532-3.7.1 After light-off has been accomplished and the system has attained a steady flow condition, hourly checks are required. A general list of checks would be:

a. Expansion tank water level.

b. Purity of demineralized water (at demineralizer inlet and outlet).

c. Flow rate through demineralizer.

d. Demineralized water circulating pump discharge and suction pressure.

e. Demineralized water circulating pump mechanical seal (no leakage allowed).

f. Temperature rise of demineralized water for each electronic component.

g. Flow rate and temperatures of water for demineralized water to seawater and demineralized water to chilled water heat exchangers.

h. Seawater circulating pump discharge and suction pressure.

i. Seawater circulating pump seal leakage is not excessive for pumps using a packing gland, an no leakage for pumps with a mechanical seal.

j. Seawater strainer differential pressure.

532-3.7.2 A record of the operational checks should be kept for analysis of any system operating problems.

NOTE

The water flow rates, temperatures, and pressures will vary depending upon combination of heat exchangers operating, power level of electronic equipment, and seawater temperature. This must be taken into account when evaluating the data.

532-3.7.3 The design values of pressure, temperature, flow rates, and so forth, for a particular system may be obtained from the applicable technical manual.

532-3.8 SECURING

532-3.8.1 Securing the system is accomplished by reversing the procedure for light-off operation. Steps are:

1. De-energize electronic equipment.

2. Allow system to circulate until heat has dissipated.

NOTE

If the auxiliary seawater or chilled water system is being used, steps 3 through 6 of the securing procedure would be replaced by closing the inlet and outlet valves of the heat exchanger.

3. De-energize dedicated seawater circulating water pump.
4. Close seawater circulating pump discharge valve.
5. Close valve from sea chest to pump suction.
6. Close overboard valves.
7. Place demineralizer switch to OFF position.
8. Close demineralizer inlet and outlet valves.
9. De-energize demineralized water circulating pump.
10. Close demineralized water circulating pump discharge valve.
11. Close demineralized water circulating pump suction valve, expansion tank outlet valve, and heat exchanger inlet and outlet valves.

SECTION 4.
MAINTENANCE AND REPAIR

532-4.1 INTRODUCTION

532-4.1.1 This section gives information on maintenance requirements which are considered to be within normal capabilities of operation and maintenance personnel aboard ship. In addition, it describes in detail, maintenance and repair procedures which may not be familiar to personnel concerned with operation and maintenance of liquid cooling systems for electronic equipment.

532-4.2 TROUBLESHOOTING GUIDE

532-4.2.1 Table 532-4-1 at the end of Section 4 is a troubleshooting guide which provides a list of problems, causes, and remedies for liquid cooling systems. Many of the corrective action items listed are considered to be within the normal capabilities of shipboard operation and maintenance personnel; for example: check pump for correct seawater flow.

NOTE

The items listed in the table are generalized and do not supersede specific system and equipment technical manuals or maintenance instructions given in the Planned Maintenance System (PMS) Maintenance Requirement Cards (MRC's).

532-4.2.2 Corrective action items that may not be familiar to shipboard personnel are discussed in detail in paragraphs 532-4.4 through 532-4.8.1.

532-4.3 MAINTENANCE REQUIREMENTS

532-4.3.1 LIQUID COOLING SYSTEM. Liquid cooling systems require the periodic maintenance described in the following paragraphs.

NOTE

Refer to specific PMS MIP onboard ship and conduct maintenance in accordance with MRC's.

532-4.3.1.1 Daily. On a daily basis:

1. Check demineralized water expansion and compression tank level.
2. Check compression tank air pressure charge.
3. Check demineralized water conductivity and resistivity.
4. Monitor demineralized water pump for unusual noise, vibration, or mechanical seal leakage.
5. Check duplex strainer and plate heat exchanger seawater differential pressure.
6. Check shell and tube seawater heat exchanger telltale drains for leakage.
7. Check all gages to ensure cooling system is operating at proper flow, pressure and temperature.
8. Vent air at manual vent points from chilled water, demineralized water and seawater systems.
9. Check IC/SM alarms at local and remote panels to ensure alarms are not activated.
10. Check piping system for leaks.

532-4.3.1.2 Weekly. On a weekly basis:

1. Inspect and check liquid cooling loop.
2. Clean and inspect seawater strainer.

532-4.3.1.3 Monthly. On a monthly basis:

1. Verify calibration of instrumentation.
2. Backflush plate heat exchanger seawater loop.
3. Clean and inspect orifice plates (18M).

532-4.3.1.4 Quarterly. On a quarterly basis:

1. Test operation of temperature regulating valve(s).
2. Test operation of demineralizer flow/no flow switch.
3. Test operation of system seawater, chilled water and demineralized water low flow and pressure switches.

4. Test operation of temperature switch with wet bulb installed.
5. Test operation of pressure switch.
6. Test operation of expansion tank low level alarm.
7. Test operation of expansion tank low level switch and indicator.
8. Inspect heat exchanger zinc anodes.
9. Test operation of temperature switch with dry bulb installed.
10. Inspect mechanical seal for leakage.
11. Clean and inspect seawater system low flow switch.
12. Test operation of flow meter.
13. Cycle all seawater system valves, lubricate and inspect.

532-4.3.1.5 Semi-Annually. On a semi-annual basis:

1. Clean conductivity sensors.
2. Test conductivity system.
3. Test and calibrate conductivity meter.
4. Test and calibrate conductivity alarm.

532-4.3.1.6 Annually. On an annual basis:

1. Clean and inspect demineralized, chilled water system low flow switches.
2. Test all system alarms and open and inspect B-51/B-52/IC/SM alarm panels.
3. Test relief valves.
4. (5 year periodicity) Submit work request to repair activity to chemically clean and hydrostatically test seawater tube and shell heat exchanger.
5. Cycle all chilled water/demineralized water system valves, lubricate and inspect.
6. Clean and inspect motor controllers and measure insulation resistance.
7. Inspect motor, lubricate bearings (non-sealed only) and measure insulation resistance.
8. Inspect pump and motor foundation, fasteners, vibration isolation mounts and grounding straps.
9. Inspect rubber and PTFE flexible hoses and their connection assemblies for leakage, deterioration, cracking, or broken wire strands.

532-4.3.1.7 As Required. Performed as necessary:

1. Clean and inspect system filters.
2. Replace demineralizer submicron filter membrane or cartridge.
3. Replace demineralizer mixed bed and oxygen cartridge.

4. Clean and inspect temperature regulating valve internal parts.
5. Clean and inspect chilled water/demineralized water heat exchanger.
6. Clean and inspect seawater tube and shell heat exchanger.
7. Backflush seawater plate heat exchanger seawater loop when differential pressure exceeds 10 PSID above clean pressure reading.
8. Flush demineralized water system.

532-4.3.1.8 Lay-Up. Maintenance procedure to be followed prior to placing equipment in Lay-Up.

1. Drain and flush electronic equipment seawater cooling system.
2. Install controller drying agent and protective covering.
3. Install approved, fire-retardant protective covering.
4. Drain system pump casings.
5. Drain electronic equipment cooling water system.
6. Drain seawater or chilled water from the heat exchangers.

532-4.3.1.9 Start-Up. Perform when placing equipment in operation from Lay-Up.

1. Remove controller protective covering and drying agent.
2. Clean and inspect controllers.
3. Remove protective coverings.
4. Fill system pump casings.
5. Fill and vent electronic equipment seawater cooling system.
6. Fill and vent electronic equipment cooling water system.

532-4.4 MAINTENANCE AND REPAIR PROCEDURES

532-4.4.1 GENERAL. Detailed maintenance and repair procedures are given in the following paragraphs.

NOTE

Where PMS is installed, conduct preventive maintenance in accordance with MRC’s.

532-4.4.2 DEMINERALIZED WATER SYSTEM. Procedures for testing, preparing make-up water, and cleaning the demineralized water system are described in paragraphs 532-4.4.2.1 through 532-4.4.2.3.3.

532-4.4.2.1 Testing. The demineralized water system requires frequent monitoring of water purity to ensure satisfactory operation. The primary means of monitoring water purity is the in-line conductivity or resistivity meter supplied with the demineralizer unit. Semi-annual cleaning of the conductivity cells, along with proper calibration of the meter is extremely important. If calibration of the meter cannot be performed, or if the conductivity cells require replacement, interim conductivity measurement can be performed by the activities listed in paragraph 532-1.3 and 532-1.3.1. High purity water systems, such as the AN/SPG-55B and AN/SPY-1 series radars, shall have a maximum conductivity of 2 micromhos/cm. Lower purity water systems, such as the AN/SQS-23 sonar (5 grains/gallon or 1.3 epm chloride maximum), ASROC heating and cooling, and the AN/SLQ-32 series ECM, which use ethylene glycol or distilled water for coolant, shall have a limit of 383 grains/gallon (100 epm) or less of chloride.

532-4.4.2.2 Preparing Make-Up Water. The primary source of make-up water at sea is distilled water from the ship's evaporators. Alternate sources of make-up water would be from the medical department or supply system. In port, deionized water is available from SIMA via a mobile water purification system.

CAUTION

Water obtained directly from the reserve feed tank or the ship's freshwater (potable) tank must not be used.

532-4.4.2.2.1 To use the ship's evaporators, the following precautions should be taken:

a. Maintain a chloride level below 0.065 epm, 10 micromhos/cm.

NOTE

For some electronic equipment the purity level will have to be increased even further by running the distilled water through a deionizer before it enters the system or by allowing it to circulate through the demineralizer before the electronics are energized.

b. A clean, capped container should be used for transporting or storing the water. If a make up water feed system is available from the ships evaporators to the expansion tank let the makeup water run for one minute before sampling. Sample shall be 10 micromhos/cm maximum.

c. The highest quality distillate obtained from the distilling plant should be used.

532-4.4.2.3 Cleaning. To clean the demineralized water system after initial construction or after modification where hot work was performed, use the cleaning procedures given in paragraphs 532-4.4.2.3.1 and 532-4.4.2.3.2 in sequence. For regular cleaning of scale and oxides which build up from prolonged operation, follow the flushing procedures of paragraph 532-4.4.2.3.3.

CAUTION

Chemical cleaning to remove or correct a serious fouling condition should not be attempted by ship's force without technical assistance from a shipyard SIMA, or fleet service personnel listed in paragraph 532-1.3 and 532-1.3.1

NOTE

Approved cleaning chemicals are WT202 chelate, citric acid, and trisodium phosphate.

532-4.4.2.3.1 The trisodium phosphate flush removes heavy oil and grease film which can accumulate in the piping system during system construction. The cleaning solution shall be prepared by mixing the following reagents in the proportion indicated commensurate with total system volume.

4 lbs Trisodium Phosphate ($NA_3\ PO_4$ -$12H_2\ O$)

(Fed Spec: O-SD-642 Type II)

(NSN: 9G 6810-00-141-6080)

2 oz General Purpose Detergent

(MIL SPEC: MIL-D-16791, Type I)

(NSN: 9Q 7930-00-282-9699)

15 gal Water, Distilled (0.065 epm chlorides max)

The following procedures apply:

1. Remove internals from all flow control fittings and flow switches, and bag and label for replacement.
2. Provide return jumpers to allow flushing through all ″dead legs″ (gage and switch lines).
3. Provide jumpers to bypass electronics components.
4. Isolate demineralizer and remove cartridges and filter.
5. Provide jumpers around heat exchangers and pumps. Isolate in-line full flow filter, and flowmeter and open bypass valve.
6. Install a temporary full flow strainer with a cotton muslin bag filter in strainer basket. Install a flushing rig where necessary to flush the segment of piping in question.
7. Premix volumes of the cleaning solution in the proportions indicated and fill and vent the segments of piping to be flushed.

NOTE

The flushing shall be accomplished in one section at a time to obtain maximum water velocity possible in each section (12 feet per second minimum in the largest pipe within each section) to be flushed. During flush inspect all piping for leaks, and repair those found before continuing.

8. Circulate the solution for two hours and until the cotton muslin bag remains free of particulate (replace bag as necessary). Maintain temperature of the flushing solution at 90°F - 100°F by using a steam to water heat exchanger which may be installed at the electronics equipment jumpers.
9. Reconnect heat exchangers, open filter and flow meter cutout valves and close bypass valves.
10. Refill and vent system as necessary and repeat step 8 with heat exchangers, filter and flow meters on line.
11. Drain flushing solution overboard to a holding container. Refill with fresh water until system is filled and

vented. Perform an open ended flush until effluent has a slick feeling when sampled between the thumb and forefinger. Open vent and drain valves to ensure fresh water removes all TSP from high points, low points, and dead legs. Containerize effluent to a holding tank for proper disposal.

12. Open vents at heat exchangers, filters and other high points to ensure all TSP is removed.
13. Continue flushing procedures using citric acid.

532-4.4.2.3.2 Citric acid flushing removes oxides, scale and debris throughout the piping system. The cleaning solution shall be prepared by mixing the following reagents in the proportion indicated commensurate with the total system volume.

6 lbs Citric Acid USP, Anhydrove, fine granular

MIL SPEC: MIL-D-11029

NSN: 9G 6810-00-141-2942

15 gal Water, Distilled (0.065 epm chlorides max)

1. Drain all rinse water from segment of piping that was TSP flushed. Premix volumes of citric acid cleaning solution in the proportions indicated above. Completely fill and vent the segment of piping to be flushed.
2. Circulate the citric acid cleaning solution for two hours through all dead legs, heat exchangers, full flow filters and flow meters (and their bypass piping) and through the demineralizer (open cutout valves). The recommended temperature range is 120°F - 140°F not to exceed 140°F, at 12 feet per second minimum velocity in the largest pipe of the segment to be flushed. During flush inspect all areas of piping for leaks and repair those found. All leaks repaired by hotwork shall be reflushed with TSP.
3. After two hours inspect muslin filter bag for particulate. Continue to flush until filter remains clean, after which piping internals shall be inspected. Pipe internal walls should be bright as a new copper penny. Repeat flushing procedures as necessary to achieve prescribed condition of cleanliness.
4. Drain the citric acid cleaning agent overboard to a holding tank. Refill and vent piping with distilled water (10 micromhos/cm max). Circulate rinse water at 150°F at the 12 fps minimum velocity. Drain the rinse water to a holding container for proper disposal.
5. Perform an open ended flush with distilled water effluent discharging to a holding container. Test the effluent for PH level and discontinue flush when PH of the effluent equals the PH of the influent. Open vent and drain valves to ensure fresh water removes all citric acid from high points, low points, and dead legs.
6. Fill and vent the entire system with distilled water, when all piping segments have been satisfactorily flushed.
7. Replace all flow regulation fittings, flow switch fittings, remove temporary strainer basket, install new filter elements in full flow filter, and install new submicron filter and cartridges in the demineralizer unit.
8. Remove steam to water heat exchanger, reconnect electronics as necessary and reconnect system pumps.
9. Circulate water through system as in normal operation. Demineralizer will bring conductivity within acceptable levels (2 micromhos/cm max). Do not energize electronics until conductivity is below 2 micromhos/cm max.

532-4.4.2.3.3 The chelate flushing agent is an effective neutral PH flushing agent which removes scale, oxide, rust, flux, chromates, phosphates, nitrates and carbonates. The cleaning solution shall be prepared by mixing the following reagents in the proportion indicated commensurate with the total system volume.

1 gal WT202 Chelating Agent

NSN: 1H 1285-00-148-7667

4 gal Water, Distilled (0.065 epm chlorides max)

The following procedures apply:

1. Drain all water from the demineralized water system.
2. Remove internals from all flow control fittings and flow switches, and bag and label internals for replacement.
3. Remove demineralizer cartridges and submicron filter.
4. Install a new full flow filter element if system is equipped with one, or install a temporary full flow filter if the system is not equipped with one.
5. Install a steam to water heat exchanger to provide regulation of cleaning solution at 90°F - 100°F.
6. Premix volumes of cleaning solution in the proportions given above in five gallon plastic containers. Fill and vent system.
7. Circulate cleaning solution through entire system using system pumps and heat exchangers dividing the total flush (4 hours) equally 2 hours through each. Flush through the demineralizer, the flow meter, the electronics cabinets, the full flow filter and bypass lines. Regulate temperature at 90°F - 100°F.
8. After one hour period install new full flow filter and shut bypass line. Circulate for the remaining three hours.
9. Drain flushing solution overboard to holding containers for shoreside disposal.
10. Refill system with distilled water and circulate for one hour. Open vent and drain valves to ensure fresh water removes all chelating agent from high points, low points, and dead legs. Dump rinse water to holding container.
11. Repeat steps 9 and 10.
12. Refill and vent with distilled water. Install new full flow filter element and circulate for thirty minutes. Test a sample of the water. Conductivity should be below 20 micromhos/cm, if not repeat rinse procedure. Testing can be accomplished by the activities listed in paragraph 532-1.3 and 532-1.3.1 or by local public works department.
13. Install new demineralizer cartridges and submicron filter. Reinstall the flow control fittings and flow switch internals. Circulate water through entire system and put demineralizer on-line.
14. Do not energize electronics until conductivity is below 2 micromhos/cm.

532-4.5 DEMINERALIZER MAINTENANCE

532-4.5.1 GENERAL. Maintenance of the demineralizer consists primarily of replacing exhausted cartridges and clogged filter membranes. Obtaining satisfactory service life from the cartridges and filter membranes is dependent on minimizing external contamination. The circulating system should be kept tight to reduce the need for make-up water which should, in any case, be as particle-free as possible and should not exceed 0.065 epm chloride, or 10 micromhos/cm.

532-4.5.2 CARTRIDGE REPLACEMENT. Figure 532-4-1 illustrates a typical demineralizer canister assembly section. A study of the illustration assists in visualizing replacement of expended oxygen or mixed bed cartridges.

532-4.5.2.1 To replace a cartridge, de-energize the demineralizer, open its circuit breaker, and take the following steps:

1. Place the FUNCTION switch on the purity meter in the OFF position.
2. Close inlet and outlet valves.
3. Open canister vent valves and drain valves. Allow the canisters to drain.

NOTE

Water spillage may be avoided by placing a container under the canisters, or a flexible tube may be connected from the canister drain to a drain line.

4. Loosen and remove the nuts, lock washers, and bolts that secure the canisters to the head assembly. Support the canisters during this operation.
5. Lower the canisters from the head assembly and remove the spend cartridges from the canisters. Inspect condition of all gaskets and canister springs and replace if required. Clean the canister internal surface removing any black oxide layers that have formed by scrubbing with a nylon bristle brush and citric acid or WT 202 chelate.
6. Remove the seals from both ends of the fresh cartridges. If seals on oxygen cartridge are broken, exposure to the atmosphere has probably deleted the cartridge and it should be discarded.
7. Place the fresh cartridges into the canisters with the large openings toward the bottom of the canisters.

NOTE

When installing fresh cartridges, ensure that the proper cartridges are installed in the canisters. Note the marking on the canisters and on the head assembly.

8. Align the canisters with the holes on the head assembly. Ensure that the cartridge boss on the head assembly is centered in the holes on each cartridges and that the gaskets are in place.
9. Secure the canisters in place evenly by tightening nuts diagonally opposite each other.
10. Open vent valves. Open inlet valve slowly. When air has been vented, close vent valves and open outlet valves.

532-4.5.3 SUBMICRON FILTER REPLACEMENT. Figure 532-4-2 illustrates a typical demineralizer submicron filter assembly section. A study of the illustration assists in replacement of the submicron filter. Cartridge type submicron filters are similar to cartridges shown in Figure 532-4-1.

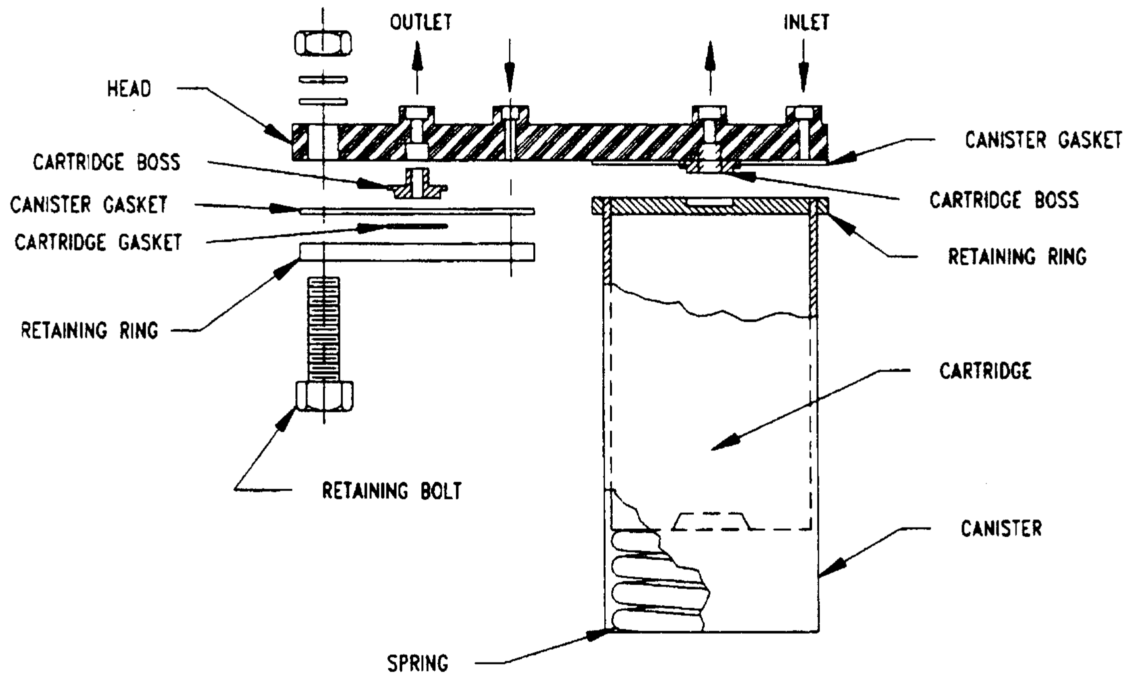


Figure 532-4-1 Typical Demineralizer Canister Assembly Section

532-4.5.3.1 To replace the filter membrane, de-energize the demineralizer, open its circuit breaker, and then proceed:

1. Unscrew the wing nuts securing filter assembly. Remove the large O-ring gasket and the used filter membrane. If the filter membrane is stuck to the fine screen, it may be washed off with isopropyl alcohol (NSN 6810-00-227-0410). Dry the fine screen carefully after using the solvent.

2. Place the fine screen in position with its edges in the groove in the head assembly.

NOTE

Ensure that the coarse screen is in position under the fine screen.

3. Remove a new filter membrane from its package, handling with care to avoid damage.

4. Place the filter membrane on the supporting screen with the rough side up.

NOTE

To determine which side is the rough side, rub the filter membrane lightly between the thumb and forefinger. The side toward the brown paper in the package will have a slightly rougher texture than the other side.

5. Center the filter membrane so its edge is lined up with the inside of the head assembly.

6. Replace the O-ring gasket, ensuring that the gasket bears against the edge of the membrane all around.

NOTE

It may be necessary to stretch the gasket to attain a snug fit; otherwise bypass leakage may occur.

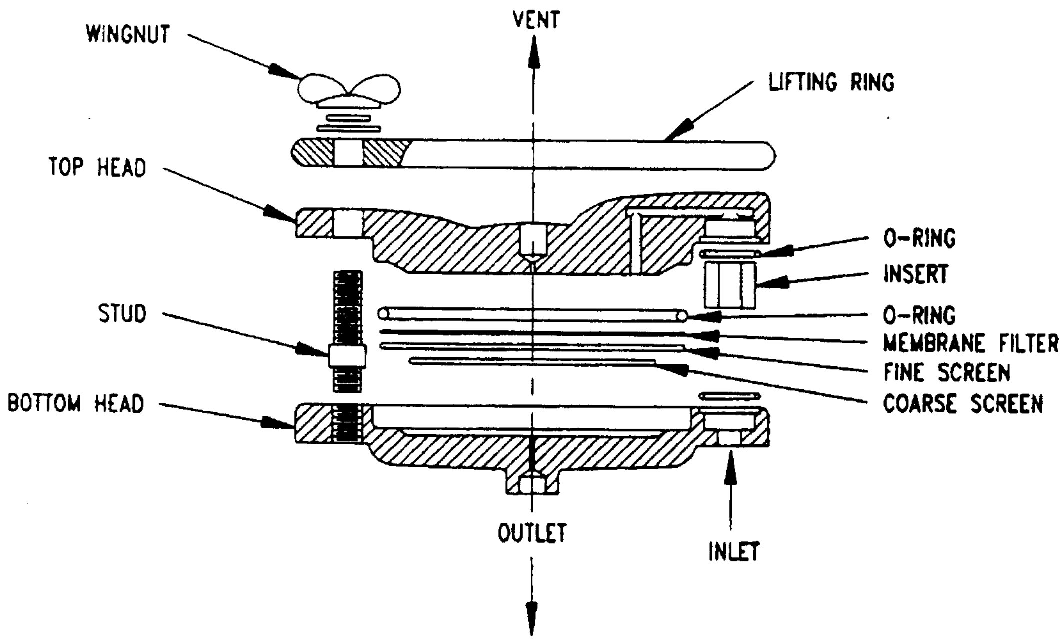


Figure 532-4-2 Typical Demineralizer Submicron Filter Assembly Section

7. Replace filter cover and secure it in place with wing nuts. Tighten the nuts evenly.
8. Start demineralizer.

532-4.6 BACTERIOLOGICAL CONTAMINATION.

532-4.6.1 GENERAL. If the filter membranes continually become rapidly clogged (within one half hour of replacement) the usual cause is the presence of bacteriological impurities. The source of bacteriological impurities may exist both in the water and in the cartridges.

532-4.6.2 SOURCE OF CONTAMINATION. The source of contamination can be determined as follows:

1. Secure the demineralizer.
2. Remove all cartridges from the canisters.
3. Replace the canisters without the cartridges.
4. Replace the clogged filter membranes with a new filter.

NOTE

Yellow stains on the filter membrane may indicate the presence of bacteriological contamination.

5. Start the demineralizer.

532-4.6.2.1 If the flow switch lamp lights before 30 minutes has elapsed, it is probable that the main system is the source of the bacteriological contamination. Proceed with system sterilization described in paragraph 532-4.6.4. If the flow switch lamp does not light, it is probable that the source of contamination is one or more of the cartridges. Proceed with elimination of bacteriologically contaminated cartridges as described in paragraph 532-4.6.3.

532-4.6.3 CONTAMINATED CARTRIDGES. Test for bacteriologically contaminated cartridges by operating the demineralizer, first with only the filter membrane and mixed bed cartridges installed.

532-4.6.3.1 If the flow rate remains satisfactory with the mixed bed cartridge installed, replace the oxygen-removal cartridges and repeat the test. If the flow rate cannot be maintained, the cartridges should be replaced with fresh ones.

NOTE

The cartridges should be stored in a cool dry area. Exposure to heat will hasten the growth of any biological contaminants which may enter the cartridges.

532-4.6.4 SYSTEM STERILIZATION. If the water is contaminated with bacteriological impurities, it will be necessary to use a sterilizing agent such as chloride to kill the organisms. A concentration of about 20 ppm of chlorine is adequate to sterilize the system. This concentration may be prepared by dissolving 1/2 ounce of 70 percent residual chlorine grade calcium hypochlorite in 100 gallons of water. The calcium hypochlorite is available for shipboard use in 6 ounce plastic tubes under stock number NSN-6810-00-255-0471.

532-4.6.4.1 With cartridges and filter removed from the demineralizer, add sufficient chlorine to the main circulating system. Allow the solution to circulate through the main circulating system and demineralizer for at least one hour. To complete sterilization, use the following procedure.

1. Drain the chlorine solution from the entire system and refill with fresh distilled water.
2. Circulate the water for 15 to 20 minutes and drain. Refill with fresh distilled water.
3. Circulate the second filing of water for about 15 to 20 minutes. Drain the system and refill with fresh distilled water not exceeding 10 micromhos/cm (0.065 epm chloride).
4. Replace the filter membranes and cartridges.
5. Operate the demineralizer.

532-4.7 TESTING ALARMS AND INTERLOCKS.

532-4.7.1 Alarms and interlocks are connected to flow, pressure, and temperature switches to provide cooling system remote monitoring. These devices may be tested easily without removal. Should testing of a switch indicate that is not within calibration limits, have an authorized calibration team perform calibration. To check the setting of a flow switch, proceed as follows:

1. Where a flow measuring device is provided directly in-line with the flow switch, throttle the inlet valve to the flow switch and monitor the flow indication on the meter for the switch set point.
2. When no flow measuring device is provided in-line with the flow switch, shut off flow to the switch and ensure that the switch will activate the alarm in the no flow condition.

532-4.7.2 A high temperature switch may be tested by operating the radar in standby condition or radiating into the dummy load to provide a heat load on the demineralized water system, and slowly closing off the flow of seawater or chilled water to increase the water temperature. If the switch probe is set in a dry well and can be removed, then place the probe in a water bath and test for switch closure electrically.

532-4.7.3 An expansion tank high level or low liquid level switch may be tested by filling or draining the tank level to the marked level to activate the alarm. When performing this check, ensure that the expansion tank is isolated from the system and the pumps are secured.

532-4.8 ADJUSTING TEMPERATURE-REGULATING VALVES

532-4.8.1 The following procedure is provided as a general guide for adjusting temperature-regulating valves. The procedure is written as being applicable to the two and three-way valve shown in Figure 532-2-3 and Figure 532-2-4 set at 92°F and 85°F, respectively.

1. Check the manual control on the temperature-regulating valves; the pointer, on the frame of the valve, should be set to mid-scale. If no pointer exists, set the manual control to the middle of the operating range to allow automatic control to function.
2. Check the operation of the thermometer at the seawater inlet to the SW/DW heat exchanger, the thermometer at the demineralized water inlet to the electronic components, and the thermometer at the chilled water supply to the CHW/DW heat exchanger.
3. Strainers should be clear, the circulating pump should be on, and all necessary valves should be open. The chilled water supply valve should be shut but all other systems should be operating.
4. Place electronic equipment in full power and observe the demineralized water temperature at inlet to electronic components.
5. Allow the system to stabilize for one-half hour at which time the demineralized water temperature should be stabilized. If the demineralized water temperature is above 85°F, adjust the knurled nut on the three-way valve to reduce the temperature.

NOTE

The nut can be turned in either direction, depending on piping arrangement and valve manufacturer.

6. The nut should be adjusted one turn, then about 15 minutes should be allowed for the temperature to stabilize.

NOTE

The lower the seawater temperature, the easier will be the adjustment due to rapid change resulting from each adjustment.

7. The knurled nut should be adjusted until the demineralized water temperature stabilizes 85°F with the electronic equipment at full power.

8. This completes the adjustment of the three-way valve.

9. Open the chilled water inlet valve to the CW/DW heat exchanger.

10. Reduce the seawater flow until the demineralized water temperature increases to 95°F. At this time the two-way valve in the chilled water supply should open, chilled water should flow, and the demineralized water temperature should stabilize at 92°F. If necessary, adjust the knurled nut on the two-way valve to obtain the desired temperature.

11. After the two-way temperature-regulating valve has been properly adjusted, open the seawater valve and note that the demineralized water temperature drops to 85°F and that the chilled water flow stops.

Table 532-4-1 TROUBLESHOOTING GUIDE

SYMPTOM	CAUSE	REMEDY
A. Circulating pump does not deliver water.	1. Air pocket or air leak in suction line.	Tighten all pipe connections. Bleed off air at pump casing and all available vents.
	2. Pump suction line not fully submerged.	Bleed air from line
	3. Speed too low.	Check voltage and current draw for proper levels.
	4. Wrong direction of rotation (check arrow).	Check power connections to motor.
	5. Foreign matter in pump impeller and basket strainer.	Check pump impeller, suction piping, and basket strainer, and clean as necessary.
	6. Pump impeller not rotating due to broken shaft or keyway.	Replace damaged parts.
B. Insufficient capacity delivered by circulating pump.	1. Air pocket or air leak in suction line.	Tighten all pipe connections. Bleed off air at pump casing and all available vents.
	2. Filter element saturated with debris (when installed).	Change filter element.
	3. Wearing rings worn.	Check clearances.
	4. Impeller damaged.	Replace damaged parts.
	5. Casing gasket defective.	Replace damaged parts.
C. Insufficient pressure delivered by circulating pump.	1. Speed too low.	Check voltage and current draw for proper levels.
	2. Air in liquid	Check for air leaks. Bleed off air at pump casing and all available vents.
	3. Impeller damage.	Replace damaged parts.
	4. Wearing rings worn.	Check clearances.
	5. Casing gasket defective.	Replace damaged parts.
D. Circulating pump vibrates or is noisy.	1. Misalignment.	Realign components.
	2. Foundation not sufficiently rigid.	Tighten all fasteners.

Table 532-4-1 TROUBLESHOOTING GUIDE - Continued

SYMPTOM	CAUSE	REMEDY
	3. Impeller partially clogged causing imbalance.	Remove, clean, and inspect for damage.
	4. Mechanical defects of pump or motor such as bent shaft, binding rotating element, or warped impeller.	Replace defective parts or replace pump or driver
	5. Pipe strain.	Piping should be arranged so not load is imposed on the pump.
E. High demineralized water system temperature.	1. Faulty temperature indicators.	Replace or calibrate temperature gages.
	2. Insufficient cooling water.	Check circulating pump.
	3. Blocked or dirty heat exchangers, flow regulators.	Check water flow rates if possible; inspect and clean as required.
	4. Air blanket in heat exchanger.	Vent heat exchanger.
	5. Insufficient chilled water flow.	Establish adequate flow and supply temperature of chilled water; check setting of 2-way temperature-regulating valve controlling chilled water flow to ensure proper operation (see paragraph 532-4.8).
	6. 3-way temperature-regulating valve malfunction.	Check temperature-regulating valve to ensure proper operation and correct temperature setting.
	7. Insufficient seawater flow.	Establish adequate flow of seawater, check strainer and heat exchanger for clogging.
F. Low demineralized water system temperature	1. Faulty temperature indicators	Replace or calibrate temperature gages.
	2. Three way temperature-regulating valve malfunction.	Check setting of temperature-regulating valve to ensure proper operation (see paragraph 532-4.8).
	3. Chilled water temperature regulating valve malfunction.	Check temperature-regulating valve to ensure tight closing at correct temperature.
G. Excessive amount of make-up required in demineralized water system.	1. Ruptured tube or tube joint failure in heat exchanger	Plug faulty tube per replacement instruction.
	2. Piping leak.	Check for leaks in Pump Room and electronics equipment and repair as required.
	3. Circulating pump seals worn	Replace mechanical seals.
H. Low outlet purity of demineralizer.	1. Exhausted demineralizer cartridges.	Replace mixed bed and oxygen cartridges (see paragraph 532-4.5.2).
I. Purity meter on demineralizer does not indicate	1. Cells not connected or connectors dirty.	Check cell connectors and cell wiring; clean cell connections.

Table 532-4-1 TROUBLESHOOTING GUIDE - Continued

SYMPTOM	CAUSE	REMEDY
	2. Faulty connectors or components	Replace as required
	3. Electrode are dirty.	Clean with alcohol, or citric acid.
J. Low flow rate through demineralizer.	1. Clogged filter element.	Replace filter element (see paragraph 532-4.5.2).
	2. Misadjusted regulating valve.	Adjust valve.
K. Demineralizer filter clogs rapidly (within 1/2 hour of replacement).	1. Growth of bacteriological impurities.	See paragraph 532-4.6.
	2. High amount of suspended solids.	See paragraph 532-4.5.3.
L. Indicating lamps at Local or Remote IC/SM alarm panels incorrectly indicate an alarm condition, or do not light when a fault condition occurs.	1. Alarm switch improperly set.	Reset switch to correct setpoint.
	2. Incorrect switch installed.	Install correct switch.
	3. Wiring not connected or misconnected.	Correct wiring.
	4. Switch is faulty.	Replace switch.
M. Excessive seawater pressure drop across PHE (greater than 10 psid above clean differential psi).	1. Excessive fouling on plates.	Backflush - clean
	2. Seaweed clogging ports.	Backflush
	3. Crushed plate(s).	Remove and replace damaged plate(s).
N. PHE fails to maintain demineralized water at proper temperature.	1. Excessive fouling on plates.	Backflush - clean.
	2. Seaweed clogging ports.	Backflush.
	3. Plate(s) installed incorrectly.	Inspect and correct.
	4. Blank plate accidently installed in pack.	Inspect and correct.
O. Leakage between PHE plates, excessive demineralized water loss traced to PHE or seawater contamination of demineralized water.	1. Damaged or bad gasket.	Replace gasket.
	2. Crushed plate(s).	Replace plate(s).
	3. Reversed or misaligned plate(s).	Inspect and correct.
	4. Over-pressurization.	Investigate and correct.
	5. Loose compression bolts	Tighten to minimum plate pack dimension.
	6. Hole in plate(s).	Replace plate(s).

Table 532-4-1 TROUBLESHOOTING GUIDE - Continued

SYMPTOM	CAUSE	REMEDY
P. Seawater leaking from the shell and tube heat exchanger telltale drain.	1. Faulty tube joint on outer tube sheet.	Plug tube to expand it tightly in tube sheet for temporary repair. Repair joint and pressure test tube sheet.
Q. Demineralized water leaking from the shell and tube heat exchanger telltale drain.	1. Faulty joint on inner tube sheet.	Expand tube and pressure test.
R. Low resistivity or high conductivity.	1. Demineralized water conductivity is to high.	Replace demineralizer cartridges (see paragraph 532-4.5.2)
	2. Alarm adjustment improperly set.	Reset alarm.
	3. Make up water is over 0.065 epm chloride content.	Follow established procedures.
	4. Seawater contaminating demineralized water system.	Check heat exchanger, plug leaking tubes. Ensure seawater pressure is lower than demineralized water pressure in heat exchanger.
S. Low firemain pressure.	1. Pressure gages out of calibration.	Replace or calibrate as necessary.
	2. Incorrect valve arguments (i.e., cutout, seachest valve partially closed).	Inspect all in-line valves for open flow.
	3. Faulty seawater pump.	Check seawater pump performance.
T. Pressure reducing station downstream pressure is incorrect.	1. Incorrect setting on pressure reduction valve.	Reset pressure reducing valve.
	2. Faulty pressure reducing valve.	Overhaul internals or replace valve.
	3. Pressure reducing valve bypassed	Reset pressure reducing valve.
U. High differential pressure across seawater duplex strainer (i.e. 5 psid above clean operating differential pressure).	1. Clogged strainer baskets.	Clean strainer baskets.
	2. Incorrect plug valve position (i.e. flow pattern).	Check plug valve flow and realign with shift handle.
	3. Strainer installed backwards	Reinstall strainer to correct position.

REAR SECTION

NOTE

TECHNICAL MANUAL DEFICIENCY/EVALUATION EVALUATION REPORT (TMDER) Forms can be found at the bottom of the CD list of books. Click on the TMDER form to display the form.